PROFILES

Professional Reflection Oriented Focus on Inquiry-based Learning and Education through Science

Bolte, C., Rauch, F. (Eds.):

Enhancing Inquiry-based Science Education and Teachers' Continuous Professional Development in Europe: Insights and Reflections on the PROFILES Project and other Projects funded by the European Commission

Book of invited presenters of the
2nd International PROFILES Conference
25th–27th August 2014,
Berlin/Germany

http://www.profiles-project.eu

ENHANCING INQUIRY-BASED SCIENCE EDUCATION AND TEACHERS' CONTINUOUS PROFESSIONAL DEVELOPMENT IN EUROPE: INSIGHTS AND REFLECTIONS ON THE PROFILES PROJECT AND OTHER PROJECTS FUNDED BY THE EUROPEAN COMMISSION

Book of invited presenters of the
2nd International PROFILES Conference
25th–27th August 2014,
Berlin/Germany

Bolte, C., & Rauch, F. (Eds.). (2014). Enhancing Inquiry-based Science Education and Teachers' Continuous Professional Development in Europe: Insights and Reflections on the PROFILES Project and other Projects funded by the European Commission. Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).
ISBN: 978-3-9816683-1-5

Editorial Office: Mira Dulle, Alpen-Adria-Universität Klagenfurt
Typesetting and Layout: Marlies Strobl, Alpen-Adria-Universität Klagenfurt
Support: Jack Holbrook, ICASE (International Council of Associations for Science Education)
Print: Kreiner Druck Klagenfurt

http://www.profiles-project.eu

The research leading to these results has received funding from the European Community's Seventh Framework Programme under Grant Agreement Number 266589. The support offered by the European Commission, through the project mentioned above, is gratefully acknowledged. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use, which may be made of the information contained therein.

SEVENTH FRAMEWORK PROGRAMME – 5.2.2.1 – SiS-2010-2.2.1
Supporting and coordinating actions on innovative methods in science education:
teacher training on inquiry based teaching methods on a large scale in Europe
Grant agreement no.: 266589

TABLE OF CONTENTS

Preface 1

Conference Programme 2

1 KEYNOTES ON PROF-IL-ES 5

1.1 The Role of Curiosity in Science Teacher Professionalism and Evidence-based Practice
Alicia C. Alonzo – Michigan State University, USA 7

1.2 Inquiry Learning and Other Evidence-based Approaches
David F. Treagust – Curtin University Perth, Australia 10

1.3 Bildung and Education through Science. A Dialogue on Didactics
Meinert A. Meyer – Fakultät für Erziehungswissenschaft, Universität Hamburg, Germany
Per-Olof Wickman – Department of Mathematics and Science Education, Stockholm University, Sweden 11

1.4 Reflections on PROFILES from a Critical Friend
Peter E. Childs – Department of Chemical and Environmental Sciences, University of Limerick, Ireland 18

2 REFLECTIONS OF THE PROFILES WORK PACKAGE LEADERS 25

2.1 Looking Back and Reflecting on the Work Carried Out So Far in PROFILES
Claus Bolte – Freie Universität Berlin, Germany 27

2.2 Management and Evaluation in PROFILES
Claus Bolte & Konstanze Scheurer – Freie Universität Berlin, Germany 30

2.3 Stakeholders Involvement and Interaction in PROFILES
Claus Bolte & Theresa Schulte – Freie Universität Berlin, Germany 34

2.4 Establishing the PROFILES Learning Environment Considering Teacher Needs towards the Paradigm ‘Education through Science’
Miia Rannikmäe & Jack Holbrook – University of Tartu, Estonia 39

2.5 From the PROFILES Continuous Professional Development Programme to the Development of a Sense of Ownership
Avi Hofstein & Rachel Mamlok-Naaman –Weizmann Institute of Science, Rehovot, Israel 44

2.6 Evaluating Students Gains in PROFILES
Claus Bolte – Freie Universität Berlin, Germany 48

2.7 PROFILES Networks and Dissemination
Franz Rauch & Mira Dulle – Alpen-Adria-Universität Klagenfurt, Austria 52

3 WORKSHOP CONTRIBUTIONS ON VARIOUS PROFILES TOPICS 57

3.1 Networks in Science Education
Franz Rauch & Mira Dulle – Alpen-Adria-Universität Klagenfurt, Austria
Gabriel Gorghiu & Laura Monica Gorghiu – Valahia University of Targoviste, Romania 59

3.2 Digital Games and Augmented Reality Applications for Learning in Science
Eleni A. Kyza & Yiannis Georgiou – Cyprus University of Technology, Cyprus 63

3.3 Scenarios – A Motivational Approach Towards Inquiry-based Learning
Anu Hartikainen-Ahia, Kari Sormunen, Ilpo Jäppinen & Sirpa Kärkkäinen – University of Eastern Finland, Finland 66

3.4 Once Upon a Time… Fairy Tales in Science Lessons
Sabine Streller – Freie Universität Berlin, Germany 70

3.5 Learning With and About Advertising in Science Education
Nadja Belova & Ingo Eilks – Universität Bremen, Germany 73

3.6 Meaningful Problem Solving: a Powerful Tool for Reasoning and Deep Learning
Liberato Cardellini – Università Politecnica delle Marche, Italy 76

3.7 How Teachers Can Learn to Reflect and Collaborate: Experiences from Latvia
Dace Namsone & Līga Čakāne – University of Latvia, Latvia 80

3.8 Technological Support for Inquiry-based Learning: Development of Digital Resources in Science Education Using Web 2.0 Tools
João Paiva, Carla Morais & José Barros – Faculdade de Ciências da Universidade do Porto
Nuno Francisco – Faculdade de Ciências da Universidade do Porto & Colégio Cedros, Colégios Fomento
Luciano Moreira – Faculdade de Engenharia da Universidade do Porto, Portugal 82

4 POSTER CONTRIBUTIONS REGARDING EVIDENCE-BASED EXPERIENCES WITHIN PROFILES 85

4.1 The PROFILES Network in Austria
Franz Rauch, Mira Dulle & Kristina Zoe Römer – Alpen-Adria-Universität Klagenfurt, Austria
Ilse Wenzl – Austrian Educational Competence Centre Biology, Universität Wien, Austria 87

4.2 PROFILES – The Case of Cyprus: The Impact of a Participatory Design-model of Inquiry-based Learning Environments on Student Motivation
Yiannis Georgiou & Eleni A. Kyza – Cyprus University of Technology, Cyprus
Demetra Paraskeva-Hadjichambi, Zoe Kofina-Michael, Andreas Hadjistyllis & George Miliotis – Ministry of Education and Culture, Cyprus 93

4.3 Continuous Professional Development and Teachers' Development of Ownership of Inquiry: The Case of PROFILES Cyprus
Eleni A. Kyza & Yiannis Georgiou – Cyprus University of Technology, Cyprus 97

4.4 Development of Giftedness within PROFILES
Josef Trna & Eva Trnova – Masaryk University, Brno, Czech Republic 101

4.5 Initial Results from PROFILES in Denmark
Klavs Fridahl, Lærke Bang Jacobsen & Jan Alexis Nielsen – University of Copenhagen, Denmark 106

4.6 Inquiry-based Science Education within the Project PROFILES in Georgia
Marika Kapanadze & Ekaterine Slovinsky – Ilia State University, Georgia 112

4.7 Teachers' Ownership towards Developing New PROFILES Modules
Marika Kapanadze & Ekaterine Slovinsky – Ilia State University, Georgia 118

4.8 See You Later 'Navigator' – PROFILES Type Learning Environments with Special Emphasis on Occupational Orientation and the Evaluation of Their Impact on Students' Attitudes
Michael Albertus, Nina Bertels & Claus Bolte – Freie Universität Berlin, Germany 122

4.9 Aspects of Science Education from a European Perspective – First Results from a Meta-analysis of the International PROFILES Curricular Delphi Study on Science Education
Marlies Gauckler, Theresa Schulte & Claus Bolte – Freie Universität Berlin, Germany 127

4.10 Bio or Non-bio? – What Should I Choose?
Silvija Markic, Felix Henning – University of Bremen; Sibylle Wohlfeil – Oberschule Findorff; Ingrid Wolters – Wilhelm-Olbers-Oberschule, Bremen, Germany 135

4.11 Science Teaching that Goes Under Your Skin: A PROFILES Module on Tattooing
Marc Stuckey, Martin Haverkamp, Stephan Kienast, Ute Knoop, Bettina Most, Herbert Schultheis, Ulrike Willeke, Torsten Witteck, Petra Wlotzka & Ingo Eilks – University of Bremen, Germany 139

4.12 PROFILES Impact! Not Only CPD: From the CPD to the Class, From the Class to Chemistry Competitions
Sofia Leyderman – Kfar Silver High-School & Ort Rogozin High-School, Kiryat-Gat, Israel
Advisors: Dvora Katchevich, Malka Yayon, Rachel Mamlok-Naaman & Avi Hofstein – The Weizmann Institute of Science, Rehovot, Israel 143

4.13 Edible Chemistry: Food for Thought Development & Implementation of Two PROFILES Modules in Israel
Batia Lifshitz-Goldreich – Yigal Alon Comprehensive High school for the Arts and Sciences, Ramat Hasharon
Adina Arbel, Bondi Yael & Halfon Emi – Branco-Weiss Rabin High School, Mazkeret-Batya
Sharon Deutsch – Shoam High-School, Shoham
Smadar Aharoni-Gerbat – Yarkon High-School, Neve-Yarak, Israel
Advisors: Dvora Katchevich, Malka Yayon, Rachel Mamlok-Naaman & Avi Hofstein – Weizmann Institute of Science, Israel 146

4.14 A Renaissance Enigma: Raphael and the Lustre Technique
Daniela Ambrosi – Liceo Scientifico Galileo Galilei, Perugia, Italy 150

4.15 With Flying Colours
Battistini Lorenza, Frattoni Pina, Gallina Anna, Celestina Crosa, Guardati Nadia, Lattanzi Cinzia,

Stortini Silvia & Terzi Morena – IPSIA "RENZO FRAU" (Istituto Professionale di Stato per l'Industria e l'Artigianato), Tolentino; Katuscia Palmili – IPSIA "RENZO FRAU" (Istituto Professionale di Stato per l'Industria e l'Artigianato), Sarnano, Italy 154

4.16 Teachers' Learning Team as a Tool to Improve Scientific Inquiry Teaching
Jelena Volkinsteine, Dace Namsone & Jazeps Logins – University of Latvia, Latvia 157

4.17 The Effects of Implementing Original PROFILES Modules in Poland
Elwira Samonek-Miciuk & Ryszard Maciek Janiuk – Maria Curie-Skłodowska University, Lublin, Poland 161

4.18 "Have You Ever Wondered Why Our Clothing Changes Color in the Disco?" A PROFILES Scenario to Contextualizing and Promoting the Study of Introductory Light, Color and Matter
José Gonçalves – Agrupamento de Escolas de Amarante & Universidade do Porto
Pedro Martins – Universidade do Porto & Colégio Ellen Key
Carla Morais, José Barros & João Paiva – Faculdade de Ciências da Universidade do Porto
Nuno Francisco – Universidade do Porto & Colégio Cedros, Colégios Fomento, Portugal 165

4.19 "Green or Mature Wine?" Can We Distinguish Them without Tasting?
Amélia Moutinho, Sílvia Machado & Maria José Pacheco – Agrupamento de Escolas Joaquim de Araújo
Carla Morais, José Barros & João Paiva – Faculdade de Ciências da Universidade do Porto
Nuno Francisco – Universidade do Porto & Colégio Cedros, Colégios Fomento, Portugal 167

4.20 A "PROFILES – Education through Science" CPD Programme – An Example of Good Practice for Science Teacher Continuous Professional Development
Ana-Maria Petrescu, Luminiţa Mihaela Drăghicescu, Laura Monica Gorghiu & Gabriel Gorghiu – Valahia University of Targoviste; Mirela Cristina Negreanu – National Centre for Staff Training in Pre-University Education, Ministry of Education, Romania 171

4.21 Results of Classroom Implementation of Modules Developed for Use in Romanian Pre-primary and Primary Education
Ana-Maria Suduc, Mihai Bîzoi, Gabriel Gorghiu & Laura Monica Gorghiu – Valahia University of Targoviste, Romania 175

4.22 Three Years of PROFILES Experience in SLOVENIA: Networking, Teacher Professional Development and Student Gains
Mira Metljak, Saša A. Glažar, Mojca Juriševič, Jerneja Pavlin, Miha Slapničar, Janez Vogrinc & Iztok Devetak – University of Ljubljana, Faculty of Education, Slovenia 179

4.23 Implementation of IBSE Strategies in Training Teachers for Health Education
Esther Charro, Elena Charro, Susana Plaza & Ángela Gómez-Niño – School of Education, University of Valladolid, Spain 186

4.24 Promotion and Evaluation of the Development of Students' Competences by Using a PROFILES Module, Based on the Analysis of STS News
Marcia Eugenio – School of Education, University of Valladolid
Mary C. Izquierdo – Institute of Secondary Education (IES) Politécnico
Elena Charro – Faculty of Education and Social Work, University of Valladolid, Spain 188

4.25 PROFILES: Developing a Continuous Professional Development Programme to Enhance Inquiry-based Science Teaching
Torodd Lunde & Shu-Nu Chang Rundgren – Department of Engineering and Chemical Sciences, Karlstad University, Sweden 192

4.26 Student Responses to a PROFILES 3-stage Teaching Module
Susanne Walan – Department of Environmental and Life Sciences, Karlstad University; Shu-Nu Chang Rundgren – Department of Engineering and Chemical Sciences, Karlstad University, Sweden 195

4.27 Teacher Ownership from the PROFILES Project Perspective
Bülent Cavas – Dokuz Eylul University, Turkey 200

5 PROFILES SCIENCE EDUCATION FAIR – PRACTICAL EXAMPLES FROM PROFILES TEACHERS 205

5.1 Pollen Exposes Food Fraud in Honey – Authentic Inquiry Learning in the Field of Palynology
Heidemarie Amon, Ilse Wenzl & Christine Heidinger – Austrian Educational Competence Centre Biology, Universität Wien, Austria 207

5.2 Fair of Innovative Science Education: "Robbery at the Jewelry Shop: Innocent or Guilty?"
Andreas Hadjistyllis & George Milliotis – Ministry of Education and Culture, Cyprus
Yiannis Georgiou & Eleni A. Kyza – Cyprus University of Technology, Cyprus 210

5.3 Experiments Supporting IBSE within PROFILES
Josef Trna, Eva Trnova, Nada Kopecka & Silvie Cervenkova – Masaryk University, Brno, Czech Republic 212

5.4 Finnish Teachers' Experiences with PROFILES Teaching
Susanne Bergström-Nyberg – Mattliden School
Marita Liukku – Mertala School
Petri Luukkainen – Joutseno High School
Maarit Maksimainen – Sampo School
Raija Malinen – Taavetti High School
Marketta Pellinen – Mertala School, Finland 214

5.5 "Bio-Plastics – a Real Alternative?" Development of a PROFILES Module for Chemistry in Grades 11/12
Marlies Gauckler, Rebecca Emmerling & Josefine Graf – Freie Universität Berlin, Germany 217

5.6 Using PREZI-Technology to Promote Inquiry Learning on Bionics: Two Further Modules
Moritz Krause, Dörte Ostersehlt, Judith Meile, Lea Griemsmann & Ingo Eilks – Universität Bremen
Torsten Mehrwald, Hans-Jürgen Runden, Uwe Heering & Steffi Mroske – Lise-Meitner-Schule, Kooperative Gesamtschule Stuhr-Moordeich, Germany 220

5.7 BONES: Whose Skeleton is This? A Grade 11–12 Biology Module on the Anatomy of the Human Skeletal System
Marco Peter Ferretti – Liceo Statale "Enrico Medi", Senigallia, Italy 223

5.8 The Implementation of Selected Modules of the PROFILES Project in Poland
Sylwester Baryła – High School in Parczew
Agnieszka Kamińska-Ostęp – Faculty of Chemistry, Maria Curie-Sklodowska University, Lublin
Katarzyna Kuśmierz – High School in Borzechów, Poland 226

5.9 CIA – Color in Action: Can You See It?
José Gonçalves – Agrupamento de Escolas de Amarante & Universidade do Porto
Nuno Francisco – Colégio Cedros, Colégios Fomento & Universidade do Porto
Carla Morais, José Barros & João Paiva – Faculdade de Ciências da Universidade do Porto, Portugal 229

5.10 Promoting IBSE in Primary and Secondary Education Through Hands-On Science Activities
Gabriel Gorghiu, Laura Monica Gorghiu, Ana-Maria Suduc & Ana-Maria Petrescu – Valahia University of Targoviste; Niculina Zuga – Constantin Cantacuzino National College Targoviste
Mihaela Anghel – Ienăchiță Văcărescu National College Targoviste
Mirela Cristina Negreanu – National Centre for Staff Training in Pre-University Education, Ministry of Education, Romania 231

5.11 Slovenian Teachers' Views About Development and Implementation of PROFILES Modules in Their Lower Secondary School Science and Biology Classrooms
Mira Metljak & Iztok Devetak – Faculty of Education, University of Ljubljana
Katja Dragar – Primary school Trbovlje
Lilijana Homovec – Primary school Črni Vrh
Tatjana Dominič Radivojevič – Primary school Ivana Babiča-Jagra Marezige, Slovenia 237

5.12 The Experience of Spanish Teacher Trainees at UVa Developing Modules During Their CPD
Elena Charro, Susana Plaza, Esther Charro-Huerga & Ángela Gómez-Niño – School of Education, University of Valladolid, Spain 243

5.13 The Blossoms of PROFILES in Karlstad
Shu-Nu Chang Rundgren – Department of Engineering and Chemical Sciences, Karlstad University, Sweden 245

5.14 Magic Pictures in Inquiry-based Learning in Switzerland
Manuel Haselhofer, Peter Labudde & Miriam Herrmann – University of Applied Sciences and Arts Northwestern Switzerland, Switzerland 248

6 CONTRIBUTIONS OF OTHER EC-FUNDED PROJECTS AT THE SCIENCE EDUCATION FAIR 253

6.1 The Pathway to Inquiry-based Science Teaching
Franz X. Bogner – Centre of Math & Science Education (Z-MNU), Universität Bayreuth, Germany 255

6.2 MARine Litter in Europe Seas: Social AwarenesS and CO-Responsibility
Doriana Calilli & Mara Di Berardo – Province of Teramo, Italy
Joana M. Veiga – Coastal & Marine Union (EUCC), Netherlands
Thomais Vlachogianni & Iro Alampei – Mediterranean Information Office for Environment, Culture and Sustainable Development (MIO-ECSDE), Greece
Sabine Pahl & Bonny L. Hartley – Plymouth University, School of Psychology, United Kingdom

Richard C. Thompson – Plymouth University, School of Marine Science and Engineering, United Kingdom
Kathrin Kopke & Thomas K. Doyle – Coastal & Marine Research Centre, University College Cork, Ireland
Thomas Maes & Eva Garnacho – Centre for Environment, Fisheries & Aquaculture (Cefas), United Kingdom; Demetra L. Orthodoxou & Xenia I. Loizidou – ISOTECH Ltd Environmental Research and Consultancy, Cyprus 259

6.3 Researching Classroom Assessment of Inquiry Competences. The ASSIST-ME Project
Jens Dolin – University of Copenhagen, Denmark 267

6.4 TEMI – Teaching Enquiry with Mysteries Incorporated
Johanna Dittmar, Dörte Osersehlt & Ingo Eilks – Universität Bremen, Germany
Dvora Katchevich, Malka Yayon, David Fortus, Ran Peleg, Avi Hofstein & Rachel Mamlok-Naaman – Weizmann Institute of Science, Israel 271

6.5 Promoting Stakeholder Engagement in Research Programming in Food and Health
Klaus Hadwiger – Life Science Center, Universität Hohenheim, Germany
Daniela Coutinho – SPI-Sociedade Portuguesa de Inovação, Portugal 275

6.6 INQUIRE: Inquiry-based Teacher Training for a Sustainable Future
Suzanne Kapelari – Universität Wien, Austria
Elaine Regan – King's College London, UK
Justin Dillon – King's College London, UK
Gail Bromley – Plant Values, London, UK
Asimina Vergou – Botanic Garden Conservation International, London, UK
Julia Willison – Royal Botanic Gardens Kew, Richmond, Surrey, UK
Costantino Bonomi – MUSE, Trento, Italy 279

6.7 STENCIL: Science Teaching European Network for Creativity and Innovation in Learning
Francesca Magrefi – Amitié, Italy 285

6.8 Ark of Inquiry: A European Project for the Widespread Dissemination of Inquiry Activities through a Network of Universities, Schools, Science Centres and Museums
Margus Pedaste, Leo Siiman & Mario Mäeots – University of Tartu, Estonia
Bregje de Vries – HAN University of Applied Sciences, Netherlands
Zacharias C. Zacharia & Marios Papaevripidou – University of Cyprus, Cyprus
Tomi Jaakkola – University of Turku, Finland
Sofoklis Sotiriou & Georgios Mavromanolakis – Eellinogermaniki Agogi, Greece 291

6.9 Pri-Sci-Net – An FP7 EU funded Project Promoting Inquiry-based Learning in Science at Primary Level of Education
Suzanne Gatt – Malta Council for Science and Technology, Malta
Annette Scheersoi – University of Bonn, Germany
Demetris Koursis – University of Cyprus, Cyprus 296

Preface

Welcome to another one – the 3rd – Book of PROFILES. This book includes contributions of colleagues involved in innovative projects who want to share their experiences on how they try to enhance scientific literacy in their countries. Besides this, four "special guests" have been invited to present their reflections on how to improve science education, focusing on both fields of education: school science practice and science teacher education. Alicia C. Alonzo from Michigan University (USA) offers insights into the "Role of Curiosity in Science Teacher Professionalism and Evidence-based Practice". In contrast, David F. Treagust from Curtin University in Perth (Australia) focuses on "Inquiry Learning and other Evidence-based Practice". Meinert A. Meyer from University of Hamburg (Germany) and Per-Olof Wickman from Stockholm University (Sweden) discuss the terms "Bildung and Education through Science" from two theoretically based viewpoints: a more general viewpoint of pedagogy (M. A. Meyer) and the perspective of science education (P.-O. Wickman).
This book includes 69 contributions presented at the "2nd International PROFILES Conference on Enhancing Scientific Literacy" (Berlin, Germany, 25th–27th August 2014). The contributions are divided into six sections, which correspond to the four formats of presentations during the conference.

The first section contains the keynote lectures (mentioned above), followed by the second section that includes the reflections of the PROFILES work package leaders on the work carried out in the project so far. In the third section, PROFILES partners provide glimpses into the workshops they will offer at the conference. Summaries of insights gained within the project, which will be presented during the Interactive Poster Session, can be found in the fourth section of the book. A very special event at this conference is the "Fair of Innovative Science Education Practice". Here, colleagues of different projects funded by the European Commission can present their work and insights into their project activities. In addition, PROFILES partners and especially the partners' science teachers who have been actively involved in the PROFILES Continuous Professional Development Programme can use this opportunity to introduce "modules for science teaching and learning", which they adapted or developed and afterwards implemented in their science classes within the PROFILES project.

The Science Education Fair contributions by PROFILES teachers as well as the presentations of colleagues of other projects funded by the EC in the FP6 and FP7 programme are published in the fifth and sixth section of this book.

With this book of invited presentations, the PROFILES Consortium tries to offer a comprehensive overview of the activities and experiences of all PROFILES partners as well as colleagues from other science education projects in Europe who followed our invitation to present their contributions at the conference.

We would like to thank all authors and presenters for their contributions and dedicated work. Furthermore, we want to thank Jack Holbrook for his supporting feedback to most of the contributions of this book, Mira Dulle and Marlies Strobl for all their efforts in the editorial work, and the team at Freie Universität Berlin – especially Sabine Streller and Konstanze Scheurer – for organizing the "2nd International PROFILES Conference on Enhancing Scientific Literacy" in Berlin and hosting all of the attendees. Only through the support and cooperation of all partners, colleagues and participants it was possible to create a forum which will become – as we both, Franz Rauch and Claus Bolte, are convinced – a successful and fruitful event and starting point for increasing Scientific Literacy in Europe and beyond.

We hope you will enjoy this book and find a lot of interesting insights into science education practice.

Claus Bolte – Freie Universität Berlin, Germany

Franz Rauch – Alpen-Adria-Universität Klagenfurt, Austria

Programme of the 2nd PROFILES International Conference on Enhancing Scientific Literacy in Europe and Beyond. Berlin, August 25th to 27th 2014

	Sun. 24.08.	***Arrival***
19.00		*Come together and Registration @ the FUB – Department of Chemistry Education, Takustr. 3*

1st	**Mon. 25.08.**	**Presenters and Title of the Presentation**
8.00		**Registration @ Fabeckstr. 34-36**
9.00		**Welcome addresses** **President of Freie Universität Berlin** **Berlin Ministry of Education, Youth and Science** **Institute of Chemistry and Biochemistry**
	Welcome	Claus Bolte and the PROFILES Consortium Members - Welcome **A brief Introduction to the 2nd International PROF_IL_ES Conference on Science Education in Europe**
9.30	**Keynote 1** **PROF**	Alicia C. Alonzo, Michigan State University, USA (Introduced by Rachel Mamlok-Naaman) **The Role of Curiosity in Science Teacher Professionalism and Evidence-Based Practice**
10.30	Break	
11.00	**Keynote 2** **IL**	David F. Treagust, Curtin University Perth, Australia (Introduced by Avi Hofstein) **Inquiry Learning and Other Evidence–based Approaches**
12.00	**Keynote 3** **ES**	Meinert A. Meyer – University of Hamburg, Germany and Per-Olof Wickman – University of Stockholm, Sweden ***Bildung* and Education through Science: A Dialogue on Didactics** (Moderator: Claus Bolte)
13.00	Lunch	
14.00	**Start of the...** (ca. 15:30 Break on individual basis)	**Workshop Session** • **Learning with and about advertising in science education** (Nadja Belova) • **Meaningful problem solving: A powerful tool for reasoning and deep learning** (Liberato Cardellini) • **The use of basic LEGO SET in science and technological education** (Bülent Cavas, Pinar Cavas, Selin Nur Sayar, Duygu Seyman, Simge Akpullukcu) • **Networks in science education** (Franz Rauch, Mira Dulle, Gabriel & Laura Gorghiu) • **Scenarios - motivation towards inquiry based learning** (Kari Sormunen, Anu Hartikainen-Ahia, Sirpa Kärkkäinen) • **Magic pictures of inquiry based learning** (Manuel Haselhofer, Peter Labudde) • **Providing PROFILES CPD programmes to science teachers – A case study** (Declan Kennedy) • **Digital games and augmented reality applications for learning in science** (Eleni A. Kyza, Yiannis Georgiou) • **Technological support for inquiry-based learning: Digital resources in science education using web 2.0** (Carla Morais, Nuno Francisco, Luciano Moreira) • **How teachers can learn to reflect and collaborate: Experience from Latvia** (Dace Namsone, Līga Čakāne) • **Fairy tales in science lessons** (Sabine Streller)
	Break	
17.00	**Introduction** (each < 5 min)	**Introduction into the Interactive Poster Session on different (PROFILES related) Topics and Perspectives: Innovation – Implementation – Evaluation – Dissemination: Impacts & Outcomes of PROFILES**
	Perspective 1	**PROFILES Innovation and Evidence** (Introduced by Miia Rannikmäe)
	Perspective 2	**Evaluating PROFILES CPD Programmes and the Development of Teachers Ownership** (Introduced by Avi Hofstein)
	Perspective 3	**Students Gains and Other Important Sources of Evidence** (Introduced by Theresa Schulte)
	Perspective 4	**Evidence from PROFILES Networks** (Introduced by Franz Rauch)
17.30	**Start of the...**	**Interactive Poster Session** with (Soft-)Drinks and (Finger-)Food
20.00		**Stay together**

2nd	Tue. 26.08.	Presenters and Title of the Presentation
8:30		Set up the Stands for Science Education Fair @ Takustr.3
9.00		@ Fabeckstr. 34-36 Impressions from the workshops and the interactive poster session
9.30	**Start of the...**	**Fair of Innovative Science Education Practice** presented by colleagues of the EC funded projects and by PROFILES teachers @ Takustr. 3
12.00	Lunch	
14.00	**Start of the...**	**Conference Excursion to the Berlin Wall Memorial** Meeting point @ Takustr. 39 (seminaris hotel)
18.30	**Evening lecture and Networking Dinner**	**Evening lecture by Klaus Roth on "Sweets for my Sweet"** @ Botanical Garden

3rd	Wed. 27.08.	Presenters and Title of the Presentation
9.00		@ Fabeckstr. 34-36 Reflection on PROFILES by the Representatives of the four WP Leader Institutions: **A brief Resume after more than 3½ Years of PROFILES**
9.30		*Questions, Comments and Recommendations from the Conference Participants*
9.45		**Let's talk about Science Education in Europe and beyond: Impressions of a Critical Attendee**
10.15		*Additional Statements and Comments from the Conference Participants*
10.30	Break	
11.00	**Keynote**	Maria Korda (EC Representative – not confirmed yet): **'Looking back to the Future' – Opportunities to Enhance Scientific Literacy by means of FP7 and Horizon 2020 projects**
11.30		*Questions and Comments of the Conference Participants*
11.45		**Final statements of the PROFILES Consortium: Good bye** End of the Conference and Opportunity to Departure (except the PROFILES Steering Committee Members)
	Lunch **Departure**	**End of the Conference**

1 KEYNOTES ON PROF-IL-ES

1.1 The Role of Curiosity in Science Teacher Professionalism and Evidence-based Practice

Alicia C. Alonzo – Michigan State University, USA

Abstract

Recent calls for "evidence-based practice" or "data-driven decision-making" expect teachers to apply "best practices" (based upon others' research) or to do something about evidence (collected and interpreted by others). In this sense, while educational researchers are scientists (or knowledge producers), teachers are treated as technicians or – occasionally – as engineers (or knowledge consumers). In this address, I argue for the importance of professional teachers taking on the role of knowledge producers and for the central role of curiosity in this process.

While there is appeal to the simple model of researchers producing clear recommendations that teachers can apply in the classroom, both the nature of teachers' knowledge and the complexity of their classroom work with students necessitate a different role for teachers. Decades of research has documented that teachers' knowledge is highly situative and contextualized (e.g. Connelly & Clandinin, 1985; Grossman, 1995; Leinhardt, 1988; Putnam & Borko, 2000). The knowledge – such as pedagogical content knowledge (PCK; Shulman, 1986; 1987) – that teachers use to inform their classroom work is not a type that can be produced by researchers or transferred directly from research to practice.

Cochran-Smith and Lytle (1999) refer to researchers' formal knowledge as "*knowledge-for-practice*", distinguishing this from both "knowledge-in-practice" – *"what very competent teachers know as it is embedded in practice and in teachers' reflections on practice"* – and *"knowledge-of-practice"* (p. 250). While both knowledge-in-practice and knowledge-of-practice rely upon evidence from teachers' classrooms, the latter is particularly significant in that it *"is generated when teachers treat their own classrooms and schools as sites for intentional investigation at the same time that they treat the knowledge and theory produced by others as generative material for interrogation and interpretation"* (Cochran-Smith & Lytle, 1999, p. 250).

While researchers may lament the fact that teachers do not "take up" research findings exactly as intended, it may be inappropriate to expect teachers to implement research results directly in their classrooms. Rather, professional teachers generate knowledge, both through the critical adaptation of others' knowledge and theory and through their own investigations.

Unlike scientists and educational researchers, whose questions are theory-driven and generalized, teachers seek to answer questions grounded in their own practice, often asking questions that *"emerge from discrepancies between what is intended and what occurs"* (Cochran-Smith & Lytle, 1990, p. 5). Teachers generate knowledge-of-practice in answer to such questions, blending curiosity about the general (what works for "most students") and curiosity about the specific children in their classrooms. While the former type of curiosity is shared with educational researchers, the latter is particular to teachers and is what distinguishes a professional teacher from a technician. Curiosity about "what works" may lead teachers to consult educational research, attend professional development workshops, talk with colleagues, etc. Applying recommended strategies or approaches may lead to further questions, as the children in a particular classroom interact with these strategies or approaches. Whether drawing upon others' research or attempting to investigate through their own research, teachers must be curious about the particular students in their classrooms: What makes these particular students unique? How do they make sense of the world? How do they learn best? What experiences, resources, etc. do they have that might support their learning? Genuinely wondering about the individuals in one's class – and gathering the evidence to answer questions such as these – is also crucial to the work of a professional teacher. Without this second, more specific form of curiosity, teachers as technicians are subject to the dictates of knowledge generated outside of the classroom that may or may not support the learning of their particular students and that may or may not align with the knowledge they have generated in and of practice.

The extent to which teachers engage in processes of knowledge generation may account for the important observation that teachers' knowledge is not simply a function of time spent in the classroom. There is evidence that classroom experience is essential for the development of PCK (e.g. Cochran, deRuiter & King, 1993; Grossman, 1990; van Driel, Verloop & de Vos, 1998). However, in my own work, I have described two physics teachers with similar content and teaching backgrounds who exhibited markedly different PCK in their interactions with students (Alonzo, Kobarg & Seidel, 2009), as well as relatively inexperienced teachers with very strong PCK and very experienced teachers with relatively weak PCK (Alonzo & Kim, 2012; Kim & Alonzo, 2012). In the latter study, interviews and classroom observations suggest that the extent to which teachers engaged with their students' ideas and exhibited curiosity about their thinking may be particularly important in developing the element of PCK that focuses on *"specific learning difficulties and student conceptions"* (van Driel et al., 1998, p. 675).

This image of teachers as knowledge producers is particularly relevant in science, given recent efforts to define scientific literacy as more than *"content knowledge of science"* (Organisation for Economic Co-operation and Development, 2013, p. 6). Today, scientific literacy also includes procedural and epistemic knowledge, or the ability to understand and engage in the processes through which scientific knowledge is generated (National Research Council [NRC], 2012; OECD, 2013). At the core of the *"inquiry-based and problem-solving approaches"* of scientific practices is *"a commitment to data and evidence as the foundation for developing claims"* (NRC, 2012, pp. 26–27). There is evidence that teachers' engagement in scientific research supports their understandings of the practice of science (e.g. Varelas, House & Wenzel, 2005) and their ability to enact inquiry-based instruction (e.g. Windschitl, 2003). Thus, teachers' engagement in evidence-based processes of generating knowledge claims about their own teaching may also support their understandings of and abilities to support students in developing the practices that are central to scientific literacy.

That curiosity is a crucial driver of scientific discoveries (e.g. Simon, 2001) is a widely accepted tenet of the "nature of science" (e.g. Eflin, Glennan & Reisch, 1999). Recognizing science teachers as both knowledge producers and as responsible for supporting students' understanding of the nature of science (as a component of scientific literacy), I argue for the role of curiosity in science teachers' work. Like Dadds (2002), I view curiosity as critical for teachers' professionalism, as the crucial driver for the generation of teachers' knowledge *in* and *of* practice.

To illustrate these ideas, I share the case of "Tim," a teacher with whom I have been working for the past several years. I discuss the way that Tim approaches his work, with a deep curiosity about his students' ideas, and how this curiosity influences his interactions both with ideas from research and evidence of his students' learning (Alonzo & Elby, 2014a). Tim's transformation of research findings and evidence have allowed him to generate crucial knowledge-of-practice that support key changes in his practice (Alonzo & Elby, 2014b), resulting in improved learning outcomes for his students (Alonzo, Robinson & Lee, 2014).

References

Alonzo, A. C., & Kim, J. (2012). Exploring teachers' pedagogical content knowledge elicited with video clips focused on student thinking. In A. C. Alonzo (Chair), *Multiple approaches to video as a tool for exploring teachers' pedagogical content knowledge*. Related paper set presented at the annual meeting of the National Association for Research in Science Teaching, Indianapolis, IN.

Alonzo, A., & Elby, A. (2014a). The nature of student thinking and its implications for the use of learning progressions to inform classroom instruction. In J. L. Polman, E. A. Kyza, D. K. O'Neill, I. Tabak, W. R. Penuel, S. Jurow, K. O'Conner, T. Lee, & L. D'Amico (Eds.), *Learning and becoming in practice: The International Conference of the Learning Sciences (ICLS) 2014, Volume 2* (pp. 1037–1041). Boulder, CO: International Society of the Learning Sciences.

Alonzo, A. C., & Elby, A. (2014b). *One physics teacher's use of a learning progression to generate knowledge about his students' understanding of force and motion*. Proposal submitted for paper presentation at the 2015 annual meeting of the American Educational Research Association.

Alonzo, A. C., Kobarg, M., & Seidel, T. (2012). Pedagogical content knowledge as reflected in teacher-student interactions: Analysis of two video cases. *Journal of Research in Science Teaching, 49*, 1211–1239.

Alonzo, A. C., Robinson, A., & Lee, M. (2014). *Beyond a misconceptions-based approach to curriculum and learning progressions: A case of high school physics*. Paper presented at the annual meeting of the National Association of Research in Science Teaching, Pittsburgh, PA.

Cochran, K. F., DeRuiter, J. A., & King, R. A. (1993). Pedagogical content knowing: An integrative model for teacher preparation. *Journal of Teacher Education, 44*, 263–272.

Cochran-Smith, M., & Lytle, S. L. (1990). Research on teaching and teacher research: The issues that divide. *Educational Researcher, 19*(2), 2–11.

Cochran-Smith, M., & Lytle, S. L. (1999). Relationships of knowledge and practice: Teacher learning in communities. *Review of Research in Education, 24*, 249–305.

Connelly, F. M., & Clandinin, D. J. (1985). Personal practical knowledge and the modes of knowing: Relevance for teaching and learning. In E. Eisner (Ed.), *Learning and teaching the ways of knowing* (pp. 174–198). Chicago, IL: University of Chicago Press.

Dadds, M. (2002). Taking curiosity seriously: The role of awe and wanda in research-based professionalism. *Educational Action Research, 10*, 9–26.

Eflin, J. T., Glennan, S., & Reisch, G. (1999). The nature of science: A perspective from the philosophy of science. *Journal of Research in Science Teaching, 36*, 107–116.

Grossman, P. L. (1990). *The making of a teacher: Teacher knowledge and teacher education*. New York: Teachers College Press.

Grossman, P. L. (1995). Teachers' knowledge. In L. W. Anderson (Ed.), *International encyclopedia of teaching and teacher education* (2nd ed.). Oxford, England: Pergamon.

Kim, J., & Alonzo, A. C. (2012). Exploring teachers' pedagogical content knowledge elicited with video clips from their own classroom instruction. In A. C. Alonzo (Chair), *Multiple approaches to video as a tool for exploring teachers' pedagogical content knowledge*. Related paper set presented at the annual meeting of the National Association for Research in Science Teaching, Indianapolis, IN.

Leinhardt, G. (1988). Situated knowledge and expertise in teaching. In J. Calderhead (Ed.), *Teachers' professional learning* (pp. 146–168). London, England: Falmer Press.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: The National Academies Press.

OECD. (2013). *PISA 2015: Draft science framework*. Retrieved from http://www.oecd.org/pisa/pisaproducts/Draft%20PISA%202015%20Science%20Framework%20.pdf (28.07.2014).

Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher, 29*(1), 4–15.

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Shulman, L.S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1–22.

Simon, H. A. (2001). "Seek and ye shall find": How curiosity engenders discovery. In K. Crowley, C. D. Schunn, & T. Okada (Eds.), *Designing for science: Implications from everyday, classroom, and professional settings* (pp. 5–18). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

van Driel, J.H., Verloop, N., & de Vos, W. (1998). Developing science teachers' pedagogical content knowledge. *Journal of Research in Science Teaching, 35*, 673–695.

Varelas, M., House, R., & Wenzel, S. (2005). Beginning

teachers immersed into science: Scientist and science teacher identities. *Science Education, 89*, 492–516.
Windschitl, M. (2003). Inquiry projects in science teacher education: What can investigative experiences reveal about teacher thinking and eventual classroom practice? *Science Education, 87*, 112–143.

1.2 Inquiry Learning and Other Evidence-based Approaches

David F. Treagust – Curtin University Perth, Australia

In this presentation, I will discuss the nature of inquiry learning and how this relates to inquiry teaching and the kinds of evidence needed to ascertain that this mode of learning and teaching is effective. First, I will consider what is meant by inquiry learning and teaching, and then will examine particular curriculum frameworks based on inquiry learning, such as Primary Connections, Model-based Learning, and Process-Oriented Guided Inquiry Learning.

The meaning of inquiry

Most countries emphasize teaching science by inquiry in policy or curriculum documents but there are differences in definition of what is meant by inquiry. Indeed, inquiry in science education is a common theme in most national curricula. However, often there are tensions between the philosophical consideration and how these are implemented in the classroom. Often the reason for not enacting inquiry learning is related to the demands of an overloaded curriculum and so-called high stakes testing. At other times, teachers lack confidence to implement inquiry-oriented teaching and so more direction and support is needed and maybe such support is absent and so no changes are made.

Primary Connections

This Australian primary school science programme, which comprises a suite of materials from early childhood to year 6, is based on the notion that learning progresses through five phases, namely, Engage, Explore, Explain, Elaborate and Evaluate. A unique aspect of the Primary Connections programme is that teaching science is linked with teaching literacy. Through an inquiry-based approach, Primary Connections is designed to develop students' knowledge, understanding and skills in both science and literacy. Recent evaluations of units of study that make up Primary Connections have shown positive impacts upon students' conceptual understanding of science concepts and inquiry skill development.

Models and modelling

Research has shown that models and modelling are important aspects in conducting science and that models can play a key role in scientific inquiry. For students to understand the role, purpose and limitations of models, they need to have a notion of the role of models. Models, as useful tools in learning science, can be used to improve explanations, generate discussion, make predictions, provide visual representations of abstract concepts and generate mental models. Consequently, models can play a significant epistemological and pedagogical role by providing learning opportunities and they play a major role in scientific inquiry. Over recent years there have been many studies showing the positive conceptual gains in knowledge and inquiry skill development in model-based learning from elementary school to university classes.

Process-Oriented Guided Inquiry Learning

POGIL is a student-centered instructional approach where students work in small groups with the instructor acting as a facilitator. In a POGIL classroom, the method of instruction effectively combines processing skills and small-group work where students work in learning teams using specially designed activities that promote mastery of the discipline content and the development of skills necessary for scientific inquiry. The POGIL-influenced instruction, which has taken place mostly in universities, has shown substantial improvement in student attitudes, retention and performance in general chemistry classes. POGIL also has been successfully implemented by researchers in a wide range of areas in chemistry such as organic chemistry, physical chemistry, biochemistry, medicinal chemistry and high school chemistry. Beyond chemistry, POGIL had been implemented with positive results in anatomy and physiology, mathematics, information technology, and atmospheric science.

So what counts as evidence?

The western medical model that uses evidence-based findings to decide on the actions of drugs or various treatments may not be suitable in educational contexts. In educational circles there are conflicting views about the extent to which this model should be followed. I will discuss the available evidence that supports the effectiveness of Primary Connections, Model-based Learning, and Process-Oriented Guided Inquiry Learning for enhancing conceptual understanding and the development of inquiry skills.

1.3 *Bildung* and Education through Science. A Dialogue on Didactics

Meinert A. Meyer – Fakultät für Erziehungswissenschaft, Universität Hamburg, Germany
Per-Olof Wickman – Department of Mathematics and Science Education, Stockholm University, Sweden

We will discuss the term “Education through Science” as a major part of the “PROFILES project philosophy” mainly from the perspectives of didactics and *Bildung*. We take as our starting point the components of the didactic triangle: the student(s), the teacher and, in our case, the science and inquiry content.

The triangle has to be elaborated particularly with regard to language and action as the didactic mediators within the triangle. We will show how language and action need to be situated contextually, institutionally and in society.

The presentation is a dialogue between Meinert Meyer (MM) and Per-Olof Wickman (PW) with Claus Bolte (CB) as moderator. In due course the audience is invited to take part in the discussion to widen the outlook.

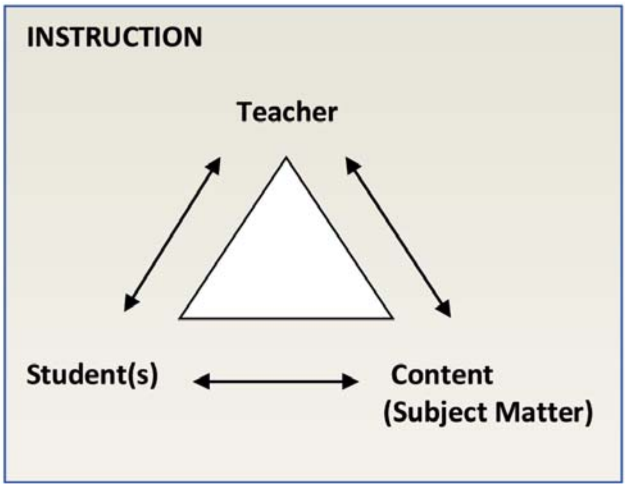


Figure 1. Structuring the field of didactics

Science education typically adopts a constructivist foundation for its research. Here we present two less well-known schools, both within the field of European didactics but with somewhat different theoretical underpinnings. These are:

Bildungsgangforschung and Bildungsgang didactics which builds, among others, on the didactic theory of the East German educational researcher Lothar Klingberg, and the Swedish *pragmatist approach* which draws mainly on concepts and ideas of the American educational philosopher John Dewey.

Bildungsgangforschung is presented by Meinert Meyer and the pragmatist approach by Per-Olof Wickman. The instructional concepts, ideas and models will be briefly summarized and compared in this text by MM and PW, stressing the theoretical perspective. Beside this, concrete examples will be given in our oral presentation.

After this we will focus on three main questions which are – in our opinion – of interest if one reflects on the meaning of "education through science" in a systematic/theoretically sound manner.

1. What are the two approaches about?
2. Why is language important for the negotiation of meaning?
3. How can education through science be of significance for young people and society?

What are the two approaches about?

MM

"Bildungsgangforschung" can be translated as *research on learner development and educational experience*, the first part of this concept defining translation being meant to indicate that students learn very much, in school and when they are not in school, in accordance with their physical and psychological development, and that they bring with them what they have learned and what they tackle right then when they participate, e.g. in science instruction. The second part of this concept defining translation identifies instruction proper, i.e. the "treatment" which students are exposed to when they are taught in school, and when they experience school life in general; but, as we know, educational experience is not restricted to schooling.

Bildungsgangforschung assumes that students are individual learners and that they develop their individuality, but that teachers are individual teachers as well. In the didactic theory of Lothar Klingberg this means that teacher and students are in a subject-position and at the same time in an object-position during instruction. The teacher makes the students to be his objects of teaching, even though he knows that they self-regulate their learning. As Klingberg puts it, the teacher guides and leads the class, but at the same time, the students cannot but organize their learning process in self-regulation.

PW

Our pragmatist approach builds on John Dewey's principle of continuity and his empirical method, "empirical method" meaning that to give learning direction, new knowledge has to be situated in a familiar practice where participants can see a need for improvements. For the students this means that they need to be part of an activity with purposes which makes them see how school subject matter helps them to become more competent in carrying out tasks. In science such melioration is typically sought from science subject matter. The starting activity for successful instruction is thus one which already allows the students to take successfully part in learning activities, as a result of their prior experiences in and out of school. However, it is of equal importance that the situation should be one which needs new science subject matter for increased competence. When subject matter helps people (learners) to deal more fruitfully with their current undertakings, the two are said to become continuous in people's experience. At the same time this means that students' discourse and practice change, i.e. when they learn.

Both the professional development of teachers using educational theory, and the teachers developing their students' learning by using science can be approached in this pragmatist way. The important question is how new knowledge can help students and teachers proceed fruitfully with what they are doing. Knowledge always has an object and this object is always part of a social activity with a history.

Why is language important for the negotiation of meaning?

MM

From a *Bildungsgang* perspective, the teachers and the students depend on "sense constructions" which they use like a filter when they engage in classroom interaction. To some extent, these sense constructions are defined, with or without the students being aware of that, by their developmental tasks, and this means that sense constructions identify the frame within which classroom communication becomes meaningful for the individual students. We have to accept, however, that sensefullness always is a subjective construction. Therefore, the language in the classroom is of greatest importance for the learning process.

Our topic, i.e. the identification of language and action as basic constituents of the didactic triangle, gets a problematic shape once we accept what the neo-pragmatist Richard Rorty (1989, p. 6) wrote about language. *"The world doesn't speak to us. Only we do."*[1]

I try an interpretation and application. Rorty shows that our life is determined by contingency and uncertainty. Our way of understanding the world has come to us in the historical process. We have been born into it. In this process, we have transformed the world views of our elders, and we have constructed a new world view and interpretation; a perspective how we see the world and ourselves in this world. But I, Meinert Meyer, did not decide to speak German, I did not decide to obtain the meagre general education I received, I did not choose a parent generation with members of them having been National-Socialists. Thus I have to accept that the language I speak and my culture are contingent. So, the question emerges: What then are criteria of choice for the language of science?

PW

From a pragmatist vantage point language is something which is part of already familiar activities, and new language should be understood as something which helps us discern and accomplish new undertakings as part of introducing students to new activities in new social constellations and so expand their world and rapport. The language of the familiar activities needs to be related to the language of science and how this new language helps students to deal with familiar problems in new ways by new distinctions and how they can act in improved ways.

How can education through science be of significance for young people and society?

MM

The question of how language and situation come together in didactic situations relates to Wolfgang Klafki's "epochaltypische Schlüsselprobleme" (key problems of the epoch). He assumes that we can identify, as basis for a school curriculum, problems which are characteristic for an epoch and which have a key function for the learner; they so to speak open the field of knowledge, in our case the field of the objects of science.

However, Klafki's approach provokes many critical questions. We have no procedure for the identification of "Schlüsselprobleme", and the role played by the different school subjects in this process remains uncleared, and, anyhow, natural science does not play too great a role in Klafki's catalogue.

There is no way then but to deconstruct the

[1] The most radical position concerning sense construction I know is that of Richard Rorty, the US-American neo-pragmatist (1931–2007). Following him means to understand whatever we experience as meaningful to be a man-made construction. Rorty writes: *"The world does not speak. Only we do. The world can, once we have programmed ourselves with a language, cause us to hold beliefs. But it cannot propose a language for us to speak. Only other human beings can do that. The realization that the world does not tell us what language games to play should not, however, lead us to say that a decision about which to play is arbitrary, nor to say that it is the expression of something deep within us. The moral is not that objective criteria for choice of vocabulary are to be replaced with subjective criteria, reason with will or feeling. It is rather that the notions of criteria and choice (including that of 'arbitrary' choice) are no longer in point when it comes to changes from one language game to another"* (Rorty 1989, p. 6).

categorical didactics of Klafki and to find a better framing theory for everyday classroom work, on a pragmatist basis. However, what does that mean in concrete? When am I a pragmatist? And when am I not?

Once more, sense construction comes in. If I see it right, we have to accept that the problems of the grown-ups, in particular the teachers' problems, are not the students' problems. The sense-constructional frame of the teacher differs from that of the students, and this, of course, fosters that in the instructional process, teacher and students often don't understand each other. "Joint action theory of didactics (JATD)", as developed by Gérard Sensevy and others, may be a supportive approach leading one step further on the way to identify the didactic quality of subject matter content and science content in particular.

PW

The choice of content cannot be merely a theoretical problem. Basically, it is a problem demanding social competence; in the end it will turn out to be a democratic problem.

The key problems of an epoch, and clearing whether or not they can become part of the school curriculum needs to be discussed widely and continuously – in society, but also locally in school.

However, choice of subject matter is not only a rational and political problem, it is also a highly empirical and practical educational problem, namely that of progression. Which are the practices and activities that make sense to young people and where can science contribute and make a difference to these problems from the students' perspective?

From a pragmatist stance the answer needs empirical research of what such progressions may look like and what activities they would involve. They also need a more general practise oriented basis about how teachers can reason to find situations which create such progression and how teachers can recognize and assess this continuity in student experience when it happens. Using didactical terminology this means didactic modelling for didactic analysis.

Such research needs to encompass all the relationships of the didactic triangle, involving both the teacher and student(s) in joint action, but also the transposed science content. Central here is clearing the question how academic science can meet school science, which is experienced as meaningful and progressive in various contexts, by the students and teachers and by stake-holders in society.

Here we have introduced the models of practical epistemology analysis (Wickman & Östman, 2002) and organizing purposes (Johansson & Wickman, 2011). But also a discussion of values, aesthetic and ethical ones, is central here. Here there is the possibility of using the concepts of taste in the sense of Bourdieu and Dewey (Anderhag, Wickman & Hamza, in press) and companion meanings (Roberts & Östman, 1998) as an aid for didactic analysis.

MM

From my (Meinert Meyer's) point of view, a key issue of subject matter didactics is a discussion of why people in general need science. In other words, the key problem is whether science education is a part of "general education" (in the sense of *Allgemeinbildung*) *and whether it can foster* education in the sense of *Bildung*.

Our first problem is that the meaning of the two terms *Allgemeinbildung* and *Bildung*, is definitely fuzzy. So we have to bring in our own definitions. Following Hans-Christoph Koller and others, *Bildung* as a process takes place when the teacher offers something to learn, e.g. by teaching in the traditional, Comenian sense of producing information which somehow reaches the brains or minds of the students; this however under condition that, within the teaching process, the students get the chance to produce their own world views and their own self-concepts.

Defining *Allgemeinbildung* is somewhat easier. This concept embraces all the subject matter content which the school administration, the principal and the teachers and society at large consider to be important for the development of the next generation in such a way that the young people can participate, as grown-ups, in life in the great societal institutions.

Based on the historical positions of Comenius, Kant, Humboldt, Klingberg, Klafki and Blankertz, *Bildung* has always been understood as "transformation" of what the teacher may offer, by the students. *Contrary to that, Allgemeinbildung has* always been understood as the result of classroom instruction proper, reconstructing the cultural heritage as it is transmitted over the centuries; but this needs an ethical foundation of classroom interaction and communication (Koller, Peukert and others).

I can now explicate a thesis, meant as provocative impulse. It may be that science is not a subject without which *Bildung* cannot be realized, and, even stronger, it may be that science is not necessary for *Allgemeine Bildung*.

We are now, with this thesis, in the field of curriculum research and I have to bring in my "apple pie" concept of *Allgemeinbildung*. The whole of the subjects taught in school is meant to produce *Allgemeinbildung*, okay. But you can take out one piece of the apple pie, e.g. science education, and leave the slot empty or put in a new subject without fear that *Allgemeinbildung* might break down because of this alteration. What then are the consequences for science education?

I might come to an end of my part of the dialogical introductory keynote, claiming that the frame produced by our present-day organisation of teaching and learning does not touch the individual, or as Bildungsgang Theory would term the subjective *Bildungsgänge* of the present-day students.

Following Heinz-Elmar Tenorth, I might argue in favour of the term '*Minimalbildung* for really all learners' (rather than the term *Allgemeine Bildung*), namely the three "Rs" (reading, writing, and arithmetic), computer literacy, and knowledge of English as world lingua franca, the driver's licence and a well-defined basic social competence. As one sees, science education does not show up in this list of Tenorth.

This leads me to a provocative question for the further discussion. Am I right suggesting that the students' participation in science education can be or even should be split up? Into one group of students, those who know that after school they want to do something related to science, and a second group of students who know that they do not want a professional/vocational career with science in it. The curriculum of this second group would really need a quality that makes it *allgemeinbildend*.

PW

The discussion of why we need school science is central to the content issue of didactics. Internationally this relates to the discussion of scientific literacy (Roberts, 2007), curriculum emphases (Roberts, 1982), Schwab's (1949) science interests and the arguments suggested by Driver, Leach, Millar and Scott (1996). One could also ask whether a general claim could be made at all about science (natural science) in general. The science subject in many countries typically includes nature, materials, the calendar, health, technology etc. Could we imagine a person today who has not received any schooling in these areas? Could we imagine a person spending their time in school just learning *Minimalbildung* without any content, of which one would be science? This would leave a school that excludes important worlds from many students who do not receive this *Bildung* from home.

At the same time I agree, the school of today has great difficulties in getting young people in general to see why the science subjects are relevant and useful. One reason may be because science today is taught from a conceptual starting point, rather than one which gives them a purposeful activity and inquiry as the outset for learning. The greatest challenge to science education research is to see how to situate science better in purposeful inquiry which can be motivating for citizens in general, that is, as *allgemeinbildend*. On a generic curriculum level science education researchers argue that there is such a connection, but we often seem to fail explaining how to teach it and how to learn students what it is.

And when should students choose their career? School is a place where students from various backgrounds meet and learn from each other. Also students from backgrounds where an academic or science career is not an option should meet this possibility before deciding their careers. Otherwise school risks becoming just an institution for sorting people according to their backgrounds. Science is therefore needed all through compulsory school for this reason.

At this point we suggest that the moderator, Claus, will intervene in order to bring in further arguments and to invite the audience to take part in the discussion.

References

Anderhag, P., Wickman, P.-O., & Hamza, K. M. (in press). *Signs of taste for science. A methodology for studying the constitution of interest in the science classroom*. Cultural Studies in Science Education.

Albertus, M., Bolte, C., & Bertels, N. (2012). Analyzing the Relevance of Science Education from Students' Perspectives regarding Developmental Tasks, Self and Prototype Attitudes and Motivation. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 75–78). Berlin: Freie Universität Berlin (Germany) / Alpen-Adria-Universität Klagenfurt (Austria).

Blankertz, H. (2001, 14th ed.). *Theorien und Modelle der Didaktik*. Juventa, München.

Combe, A., & Gebhard, U. (2007). *Sinn und Erfahrung. Zum Verständnis fachlicher Lernprozesse in der Schule*. Opladen and Farmington Hills: Verlag Barbara Budrich.

Comenius, J. A. (1657/1957) Didactica magna. In *Opera Didactica Omnia*. Vol. I, Czechoslovakian Academy of Sciences, Prague, Main Editor Otocar Chlup (pp. 1–196). Translation into English. M.W. Keatinge (1896, Oxford, Facsimile reproduction Kessinger Publishing's Rare Mystical Reprints without year and place).

Dewey, J. (1902/2008). *The Child and the Curriculum. Including The School and Society*. New York: Cosimo Classics.

Driver, R., Leach, J., Millar, R., & Scott, P. (1996). *Young people's images of science*. Buckingham: Open University Press.

English, A.R. (2013). *Discontinuity in Learning. Dewey, Herbart, and Education as transformation*. Cambridge University Press 2013.

Gauckler, M., Schulte, T., & Bolte C. (2014). Aspects of science education from a European perspective – First results from a meta-analysis of the International PROFILES Curricular Delphi Study on Science Education. In: C. Bolte & F. Rauch (Eds.), *Enhancing Inquiry-based Science Education and Teachers Continuous Professional Development in Europe: Insights and reflections on the PROFILES Project and other Projects funded by the European Commission* (pp. 125–132). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria Universität Klagenfurt (Austria).

Johansson, A.-M., & Wickman, P.-O. (2011). A pragmatist approach to learning progressions. In B. Hudson & M. A. Meyer (Eds.), *Beyond Fragmentation. Didactics, Learning, and Teaching in Europe* (pp. 47–59). Leverkusen, Germany: Barbara Budrich Publishers.

Klafki, W. (1995). On the Problem of Teaching and Learning Contents from the Standpoint of Critical-Constructive Didaktik. In S. Hopmann & K. Riquarts (Eds.), *Didaktic and/or Curriculum* (pp. 187–200). Kiel: IPN Kiel. Vol. 147.

Klafki, W. (1985/1991). *Neue Studien zur Bildungstheorie und Didaktik*. Beltz, Weinheim und Basel. Darin. Grundzüge eines neuen Allgemeinbildungskonzepts. Im Zentrum. Epochaltypische Schlüsselprobleme (pp. 43–81).

Klingberg, L. (1962). *Pädagogische Führung und Selbsttätigkeit in der sozialistischen Schule*. Berlin (Ost): VEB Deutscher Verlag der Wissenschaften.

Klingberg, L. (1987). Überlegungen zur Dialektik von Lehrer- und Schülertätigkeit im Unterricht der sozialistischen Schule. Potsdamer Forschungen, Reihe C, Heft 74. Potsdam: Pädagogische Hochschule „Karl Liebknecht".

Koller, H.-C. (Ed.). (2008). *Sinnkonstruktion und*

Bildungsgang. Zur Bedeutung individueller Sinnzuschreibungen im Kontext schulischer Lehr-Lern-Prozesse. Opladen and Farmington Hills: Barbara Budrich Publishers.

Koller, H.-C. (2013). *Bildung anders denken. Einführung in die Theorie transformatorischer Bildungsprozesse*. Stuttgart: Verlag W. Kohlhammer.

Lechte, M.A. (2008). *Sinnbezuge, Interesse und Physik*. Opladen and Farmingtton Hills: Verlag Barbara Budrich.

Meyer, M.A. (2012). Keyword: Didactics in Europe. *Zeitschrift für Erziehungswissenschaft, 15*, 449–482.

Meyer, M.A. (2008). Unterrichtsplanung aus der Perspektive der Bildungsgangforschung. In M.A. Meyer, M. Prenzel, & S. Hellekamps (Eds.), *Perspektiven der Didaktik* (pp. 117–138). Sonderheft 9 der Zeitschrift für Erziehungswissenschaft.

Meyer, M.A. (2011). Professional Teacher Development and Educational Experience. In B. Hudson & M.A. Meyer (Eds.), *Beyond Fragmentation. Didactics, Learning, and Teaching* (pp. 404–422). Opladen and Farmington Hills: Barbara Budrich Publishers.

Meyer, M.A., & Meyer, H. (2007). *Wolfgang Klafki. Eine Didaktik für das 21. Jahrhundert?* Weinheim, München und Basel: Beltz Verlag.

Peukert, H. (1998). Zur Neubestimmung des Bildungsbegriffs. In M.A. Meyer & A. Reinartz (Eds.), *Bildungsgangdidaktik. Denkanstöße für pädagogische Forschung und schulische Praxis* (pp. 17–29). Opladen: Verlag Leske + Budrich.

Roberts, D. A. (1982). Developing the concept of "curriculum emphases" in science education. *Science Education, 66*, 243–260.

Roberts, D. A. (2007). Scientific literacy/science literacy. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of Research on Science Education* (pp. 729–780). Mahwah, New Jersey, USA: Lawrence Erlbaum Associates.

Roberts, D. A., & Östman, L. (Eds.). (1998). *Problems of meaning in science curriculum*. New York. Teachers College Press.

Rorty, R. (1989). *Contingency, Irony, and Solidarity*. Cambridge University Press, Cambridge etc.

Schenk, B. (Ed.). (2005). *Bausteine einer Bildungsgangtheorie*. Wiesbaden: VS Verlag für Sozialwissenschaften.

Schwab, J. (1949). The nature of scientific knowledge as related to liberal education. *Journal of General Education, 3*, 245–266.

Sensevy, G. (2011). *Le sens du savoir. Élements pour une théorie de l'action conjointe en didactique*. Brussels: Group de boeck, rue des Minimes 39.

Tenorth, H.-E. (1994). *"Alle allles zu lehren" Möglichkeiten und Perspektiven allgemeiner Bildung*. Wissenschaftliche Buchgesellschaft Darmsstadt.

Westbury, I., Hopmann, S., & Riquarts, K. (Eds.). (2000). *Teaching as a Reflective Practice. The German Didaktik Tradtion.* Lawrence Erlbaum Associates Publishers, Mahwah, New Jersey, and London 2000.

Wickman, P.-O., & Östman, L. (2002). Learning as discourse change. a sociocultural mechanism. *Science Education, 86*(5), 601–623.

1.4 Reflections on PROFILES from a Critical Friend

Peter E. Childs – Department of Chemical and Environmental Sciences, University of Limerick, Ireland

I would like to thank Claus Bolte and the PROFILES consortium for the opportunity to attend the 1st International PROFILES Conference on Stakeholders' Views and the invitation to make some reflections as a critical friend.

Some strengths of PROFILES:

- The central role of CPD for teachers in the project.
- The role of teachers as equal partners with science educators.
- The focus on the development, testing and dissemination of exemplar materials.
- The emphasis on developing scientific literacy along with science.

This is supported by the recognition in many recent reports of the key role of the teacher in any education reform or innovation.

> *"The joint efforts of scientists, teacher educators and science teachers are required to successfully address the challenges of science education."* (Gago, 2004)

> *"Teachers are key players in the renewal of science education."* (Rocard, 2007)

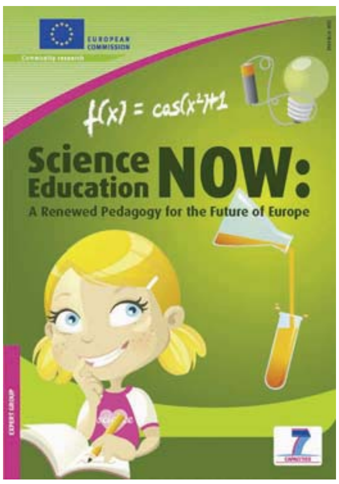


Figure 1. The Rocard report

> *"Good quality teachers, with up-to-date knowledge and skills, are the foundation of any system of formal science education."* (Osborne & Dillon, 2008)

> *"The quality of an education system cannot exceed the quality of its teachers."* (Barber and Nourshed, 2007)

My remarks are structured under the following headings:

1. Should IBSE be the only show in town?
2. How much national impact does PROFILES have?
3. How can the outcomes of PROFILES be disseminated more widely?
4. How can we ensure sustainability?
5. How do measure the success of IBSE?
6. How does PROFILES relate to the other EU projects?

1. Should IBSE be the only show in town?

I have some concerns that since the Rocard Report (Rocard, 2007) the EC has decided to put all its science education eggs in one basket – inquiry-based science education (IBSE). This report recommended (Figure 1):

> *"A reversal of school science-teaching pedagogy from mainly deductive to inquiry-based methods provides the means to increase interest in science. Inquiry-based science education (IBSE)* ***has proved its efficacy*** *at both primary and secondary levels in increasing children's and student's interest and attainment levels while at the same time stimulating teacher motivation."* (Rocard, 2007) (my emphasis)

This report led to the EC making IBSE the major focus of its FP6 and FP7 Science and Society calls, which have led to dozens of projects which are focused on IBSE.

Some of these project logos are shown in Figure 2 and details of all science education projects are available on the Scientix website (http://www.scientix.eu/web/guest/home).

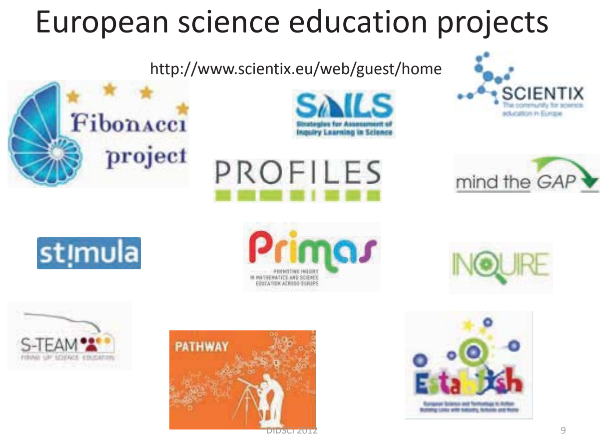


Figure 2. A small selection of the IBSE-focused EC projects

The IBSE bandwagon has also been reinforced by the recommendations of the IAP International Conference: *Taking inquiry-based science education (IBSE) into secondary education* (IAP, 2010) and the report of ALLEA *A Renewal of science education across Europe* (ALLEA, 2012).

Surely they must be right as the great and the good in European science education are all endorsing IBSE as *the* way to improve and develop school science education in the future.

There is always a danger in education of following the latest fad and fashion to the exclusion of other approaches, often without a firm basis in evidence. Chaddock (1998) said:

> *"Teachers call it the "reform du jour," and for many, it's the biggest challenge at the start of any school year. That's when the latest idea for how to improve student performance kicks in."*

The book Educational Fads (Paul and Elder, 2007) looks a number of educational fads, including inquiry-based learning and says this about the danger of following the latest fad:

> *"The history of education is also the history of educational panaceas, the comings and goings of quick fixes for deep-seated educational problems. (...) By "fad" we mean an idea that is embraced enthusiastically for a short time. In schooling, this typically means a short-lived emphasis on a seemingly wonderful new idea that will transform teaching and learning without much effort on anyone's part. Since by definition a fad will quickly come and go, it cannot be expected to improve instruction in any significant way."* (Paul and Elder, 2007)

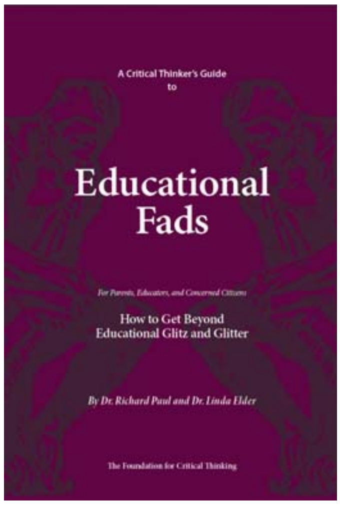


Figure 3. A Critical Thinker's Guide to Educational Fads

The important question to ask is IBSE supported by the evidence? The answer seems to be no. The book *Visible Learning: A synthesis of over 800 meta-analyses relating to achievement* by John Hattie presents the results of 800 meta-analysis of >50,000 studies of educational strategies involving >200 million children worldwide. Inquiry-based learning is well down the list of successful strategies (86th out of 138) and doesn't make it above his threshold Size Effect of 0.40. This result is stronger because it looks at the results of many studies across all levels of education and many subjects. In a controlled study in science education by Cobern et al. (2010), inquiry methods and direct instruction gave the same gain in understanding scientific concepts and they said this:

> *"Some claims for inquiry methods regarding understanding the nature of science are not sufficiently well supported by evidence."* (Cobern et al., 2010)

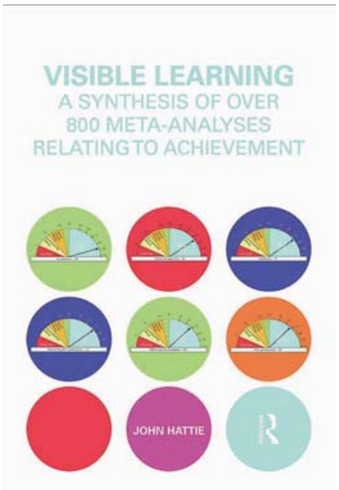


Figure 4: Visible Learning by John Hattie

My question to PROFILES and other EC-funded IBSE projects: does the research evidence support us putting all our emphasis for improving school science education on IBSE when other educational strategies have been shown to be more effective in raising student achievement?

2. How much national impact does PROFILES have?

I don't know the answer to this question, which will vary from country to country in PROFILES, but I raise some issues.

a) Projects are run by enthusiasts for enthusiasts. This is a well-known fact that the people who get involved in science education projects are committed, keen and enthusiastic, whether they are science researchers or school teachers. When the current project is finished these people usually move on to some new project.
b) How much impact outside the project schools does PROFILES have? I don't know the answer but for any project to have a long-term impact it must escape from the confines of the project schools.
c) Is it a passing enthusiasm or a long-term feature of science education? Is IBSE just the latest fad (as I suggested above), with a limited lifetime, or will it become a major feature of European science education for the future? Should it be one amongst a set of useful science teaching strategies rather than the only one?
d) Danger of the impact being too local i.e. being confined only to the project schools and the project countries and not having any wider impact.
e) How does it relate to other FP7 projects in the same country? I know that in Ireland, as one example, there are several EC IBSE projects running (PROFILES, ESATABLISH and SAILS) and at least two other in negotiation (TEMI and Chain Reaction). What is the knowledge of each project among the others? Is there any collaboration or cooperation or sharing of results? Is each project just affecting their group of teachers and science educators, with only limited impact on the totality of science education in that country (or in Europe as a whole)?

3. How can the outcomes of PROFILES be disseminated more widely?

These ideas lead us to the question of the future dissemination of PROFILES principles and materials. The challenge to the PROFILES group is how to disseminate the PROFILES philosophy and materials in:

a) Within the partner countries outside the PROFILES team, so as to have a wider impact and involve more schools and more science teachers;
b) Countries outside the project countries, who have not been involved.

There is a danger of PROFILES (and all the other IBSE projects) remaining as reports on a shelf and a fading memory of friends and nice meetings.

If I may steal a model from biology, I would like to think of the problem of dissemination of PROFILES as being like infection by a virus and ask 'How can PROFILES go viral?' There are several stages (as I understand it) in the way a virus infects a population:

- We need a potent virus (good idea, approach, materials – PROFILES).
- We need a vector (project teachers).
- We need a method of transmission (website, publications, conferences).
- We need a target population (science teachers).
- *We need time for infection to be established.*

This is a long-term project and all EC FP7 projects have a limited lifetime and when the funding drives up, so does the efforts to develop and disseminate the ideas. It is thus very important for the modules developed in each country to be made available and shared through an internet platform and publicised widely, before the project funding stops.

4. How can we ensure sustainability?

We must first say that dissemination and sustainability are not the same things.

Sustainability refers to the development and continuance of a project after the funding stops. Too often when this happens, the enthusiastic science educators move on to a new project and the teachers go back to their old ways. There may be some fading remnants of the project but we cannot guarantee its sustainability or long-term viability or effect on the national education system.

We have to ask the question: 'How do we infect the education system permanently with the PROFILES virus?'

A key problem in sustainability is changing the existing education system in a country, and embedding new ideas within the system. There are a number of problems that make this difficult:

- Traditional, entrenched views (principals, teachers, inspectors, examiners).
- Constraints of the existing science curriculum.
- The examination and assessment strait-jacket.
- The time problem in schools.

Going back to my initial thoughts, the science teacher is the key (and the barrier) to change.

- How do we change a science teacher's existing practices, philosophy and mindset?
- In order to effect change a teacher must want to change or see the value of change in their school.
- Change takes time – 80 hours has been suggested as the time it takes to change someone's entrenched practice, and most CPD is shorter than this and often not sustained.

There is a gap between theory and practice, and between science education research and science teaching and learning (Childs, 2012). Bridging that gap is one of the key challenges to projects like PROFILES in making their work sustainable. As Yogi Berra famously said:

> *"In theory there is no difference between theory and practice. In practice there is."*

5. How do measure the success of IBSE?

One of the key questions that PROFILES and the other IBSE projects have to answer is: 'How do we measure the success of IBSE and assess its effectiveness?'

a) Should we be evaluating the success of PROFILES in each country separately?
b) How do we measure its success? *On teachers? On students? On the education system?*
c) Are we measuring the effect of PROFILES or the effect of the enthusiastic teacher?
d) Is the investment in IBSE across the EU good value for money and is it having any lasting impact on science education?

I don't have answers to these questions but I think they are important ones to ask. Maybe we should take a lesson from John Hattie and look for the Size Effect on student achievement as the measure of success of PROFILES.

6. How does PROFILES relate to the other EU projects?

My final question relates to the proliferation of IBSE projects in Europe, to the exclusion of other approaches to improving science education, and how they relate to each other.

a) There are many EU FP7 projects in the area of IBSE?
b) How do they relate to each other? Is there: Overlap? Duplication? Transfer between projects? Agreed way of evaluating success?
c) We need a meta-analysis of all the EC-funded IBSE projects to draw out general findings, identify best practice and best materials etc.

The ProCoNet and the new Comenius project, INSTEM, outlined at the conference by Peter Gray, is a welcome initiative. We need a synthesis, a meta-analysis of all the IBSE projects to ensure all that money was not wasted and that the effective methods and resources developed through the various projects are made available to everyone.

A final message

- In improving science education in Europe there is no single silver bullet that will solve all our problems.
- PROFILES is not 'the' answer – but we hope it is part of the answer.
- IBSE should only be one of the teaching approaches a science teacher can draw on in their practice, but not the only one.
- The EU needs to invest more widely in science education research and development, not just in IBSE.

At the end of the day, what teachers do is what matters most. I would like to close with a quotation from John Hattie.

> Research suggests that
>
> *"visible teaching and learning occurs when learning is the explicit goal: when there is feedback given and sought and when there are active, passionate, and engaging people, including teachers, students, and peers participating in the art of learning."* (Hattie, 2009)

I would like to make a final plea for all aspects of our teaching to be research-informed (Figure 5): pedagogy, curriculum and assessment, and IBSE surely has some part, if not a major part, to play in this. (Childs, 2012)

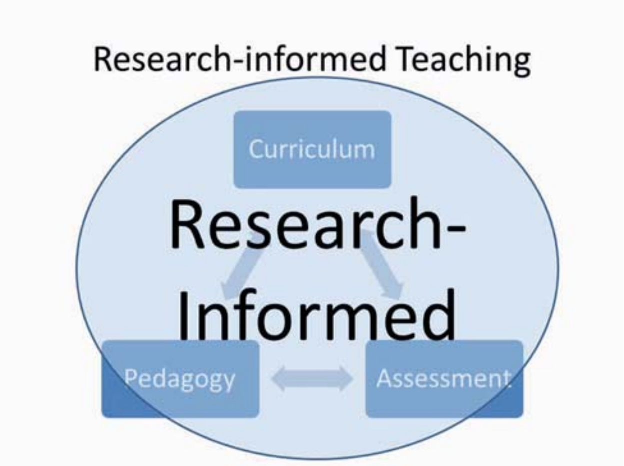


Figure 5: Research-informed teaching

References

ALLEA, (2012). *A renewal of science education in Europe: Views and Actions of National Academies*. Retrieved from: http://www.allea.org/Content/ALLEA/WG%20Science%20Education/ALLEA%20Report_A%20renewal%20of%20science%20education%20in%20europe.pdf (21.06.2014).

Barber, M., & Nourshed, M., (2007). *How the world's best performing schools systems come out on top*. Retrieved from: http://www.smhc-cpre.org/wp-content/uploads/2008/07/how-the-worlds-best-performing-school-systems-come-out-on-top-sept-072.pdf (21.06.2014).

Chaddock, G.R., (1998). Resisting education's fads. *Christian Science Monitor, 90*(190), B1. Retrieved from: http://www.csmonitor.com/1998/0825/082598.feat.feat.2.html (21.06.2014).

Childs, P.E., (2012). From SER to STL: translating science education research into science teaching and learning. Krakow: *Proceedings DIDSCI 2012*.

Cobern, W.W., Schuster, D., Adams, B., Applegate,

B., Skjold, B., Undrieu, A., Loving, C.C., & Gobert, J.D., (2010). Experimental comparison of inquiry and direct instruction in science. *Research in Science & Technological Education 28*(1) 81–96.
Gago, J. M. (2004). *Increasing Human Resources for Science and Technology in Europe*, Brussels: EC. Retrieved from: http://ec.europa.eu/research/conferences/2004/sciprof/pdf/final_en.pdf (21.06.2014).
Hattie, J. (2009). *Visible Learning, A synthesis of over 800 meta-Analyses relating to achievement*, 2nd Edition, Routledge.
IAP. (2010). *Taking inquiry-based science education (IBSE) into secondary education*, Conference Proceedings, York. Retrieved from: www.interacademies.net/12238/2951/12250/15174.aspx (21.06.2014).
Osborne, J., & Dillon, J. (2008). *Science Education in Europe: Critical Reflections*, London: Nuffiled Foundation. Retrieved from: http://efepereth.wdfiles.com/local--files/science-education/Sci_Ed_in_Europe_Report_Final.pdf (21.06.2014).
Paul, R., & Elder, L. (2007). *A Critical Thinker's Guide to Educational Fads*, Tomales, USA: The Foundation for Critical Thinking.
Rocard, M. (2007). *Science Education NOW: A renewed Pedagogy for the Future of Europe,* Brussels: European Commission. Retrieved from: http://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf (21.06.2014).

2 REFLECTIONS OF THE PROFILES WORK PACKAGE LEADERS

2.1 Looking Back and Reflecting on the Work Carried Out So Far in PROFILES

Claus Bolte – Freie Universität Berlin, Germany

Looking back to when everything started

In summer 2008, when the FP6 funded project "PARSEL – Popularity and Relevance of Science Education for Scientific Literacy" (PARSEL, 2006-2009; Nielsen et al., 2008) was almost finished, a group of colleagues came together at the final consortium meeting to discuss possibilities of continuing the successful work started within the PARSEL project. This was the starting point of a new initiative which agreed to cooperate in order to create a new and innovative project proposal which could be sent to the European Commission in the context of the FP7 Science in Society programme, hopefully meeting the criteria of the FP7 "Cooperative and Supportive action" call of the EC. After two ambitious attempts of submitting a promising proposal, the core group[1] finally came up with a project proposal – called "PROFILES" – which convinced the peer review committee of the European Union and was successfully evaluated by the committee. This – I would say – was the birthday of the PROFILES project (PROFILES, 2010; Bolte et al., 2011; 2012).

The 'Birthday' of PROFILES

In summer 2010, the designated coordinator – the Freie Universität Berlin (Germany) – started the negotiation processes with the EC officers to bring the "PROFILES" project to life. Finally, in December 2010, the PROFILES consortium as a whole met for the first time in Berlin to start their ambitious work within this demanding project.

For those who are not very familiar with the PROFILES project and its cooperative and supportive actions, I will try to make a long story short and summarize the PROFILES framework, aims and structure in a few sentences:

1. PROFILES is the acronym of "Professional Reflection Oriented Focus on Inquiry-based Learning and Education through Science" and the name of a consortium consisting of colleagues from 22 institutions in 21 different countries (see Figure 1 and Picture 1).
2. The PROFILES project activities are aiming at the *Dissemination (WP8)* of *IBSE* (Inquiry-based Science Education) through the adaption, development and improvement of innovative *Learning Environments (WP4)* and by conducting (long-term) T*eacher Training* courses *(WP5)*. The PROFILES CPD programmes are created based on pedagogically and theoretically sound models of professionalization and realized in order to raise the self-efficacy of science *Teachers* to take *Ownership (WP6)* and to reduce their professional concerns about developing more effective ways of teaching science to their students in order to enhance their *Students Gains (WP7)*. The activities within the PROFILES project are – as we (the PROFILES members) can show empirically – supported on the one hand by the *Involvement of Different Stakeholder Groups (WP3)* and on the other hand by vivid *Cooperation and Support* actions *(WP2)* of the PROFILES consortium members, as well as by promoting *Management* structures *and* thorough internal and independent external

[1] The core group of the "PROFILES" initiative consisted of: Franz Rauch from the Alpen-Adria-Universität Klagenfurt (Austria), Miia Rannikmäe and Jack Holbrook from the University of Tartu (Estonia), Avi Hofstein and Rachel Mamlok-Naaman from the WEIZMANN Institute of Science (Israel) as well as Claus Bolte and Sabine Streller from Freie Universität Berlin (Germany). The group was supported by Wolfgang Gräber, the coordinator of the PARSEL project, from the IPN Kiel (Germany) and who became later the Independent External Evaluator of the PROFILES project.

Evaluation processes *(WP1)* (see Figure 2).

3. The work to be carried out within the four years of the PROFILES project life span is divided into eight interdependently connected work packages (see Figure 3).

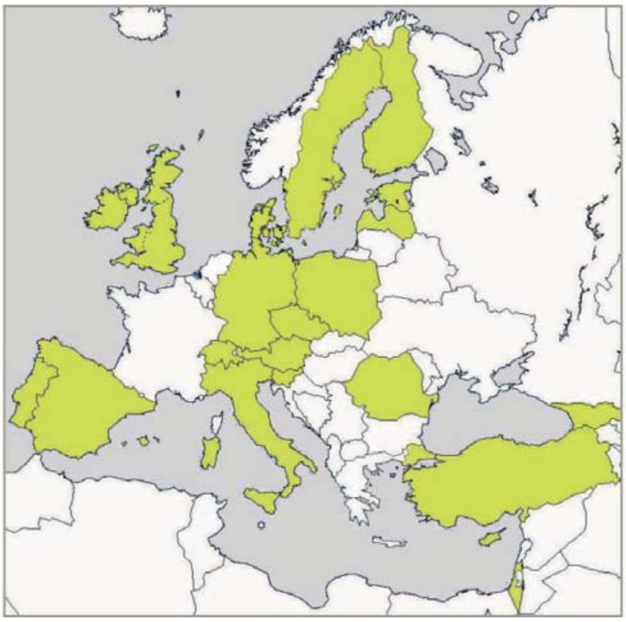


Figure 1. Overview of countries involved in the PROFILES project

The PROFILES Consortium consists of: Freie Universität Berlin (Coordinator, Germany); Alpen-Adria-Universität Klagenfurt (Austria); Cyprus University of Technology (Cyprus); Masaryk University Brno (Czech Republic); University of Copenhagen (Denmark), University of Tartu (Estonia); University of Eastern Finland (Finland); Ilia State University Tiblisi (Georgia); University of Bremen (Germany); University College Cork (Ireland); Weizmann Institute of Science (Israel); Universita Politecnica delle Marche (Italy); University of Latvia (Latvia); University of Marie Curie-Sklodowska (Poland); University of Porto (Portugal); Valahia University Targoviste (Romania); University of Ljubljana (Slovenia); University of Valladolid (Spain); University of Karlstad (Sweden); University of Applied Sciences Northwestern Switzerland (Switzerland); Dokuz Eylul University (Turkey); International Council of Associations for Science Education (ICASE, UK).

To those who would like to get more detailed information about the PROFILES project, its theoretical background and philosophy, the activities of the partners and about the outcomes

Picture 1. Colleagues of the PROFILES Consortium and attendees at the "1st PROFILES International Conference on Stakeholders Views" in Berlin, September 2012

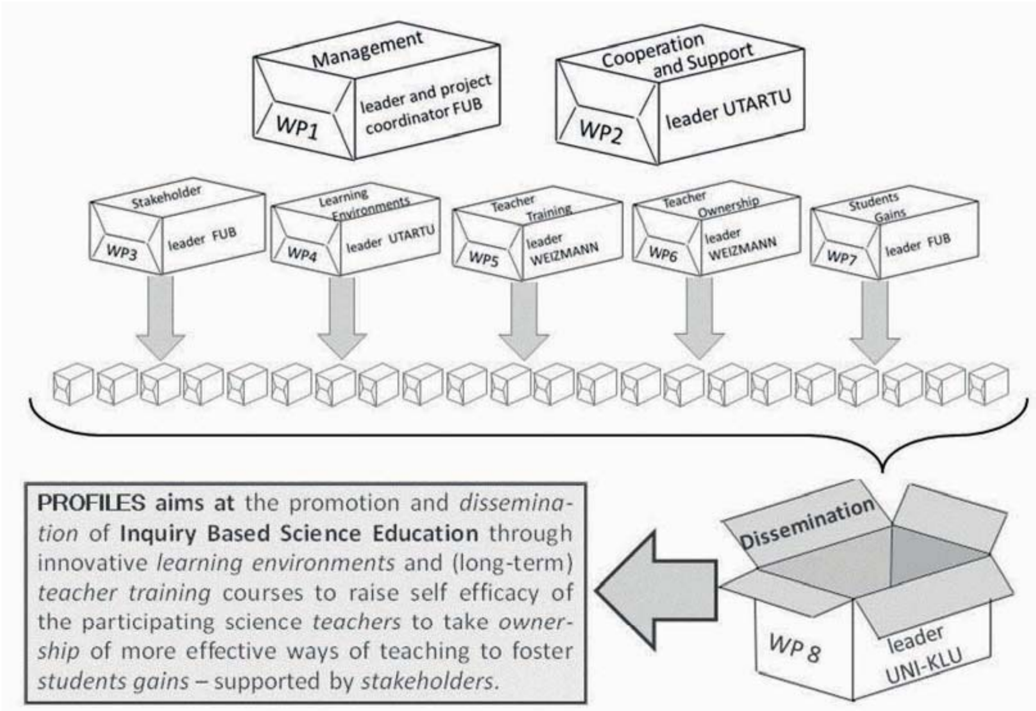


Figure 2. PROFILES work packages and aims

achieved so far, I recommend taking a look at the PROFILES International Website (www.profiles-project.eu) and/or visiting one of the 22 local websites of the PROFILES partners. There, the three "Books of PROFILES" can be downloaded. On the PROFILES websites the six volumes of the PROFILES Newsletters can also be found. The PROFILES Newsletters are provided in English and in German; selected parts of the PROFILES Newsletters have also been translated into the partners' local language(s) and published on the partners' national PROFILES websites as well.

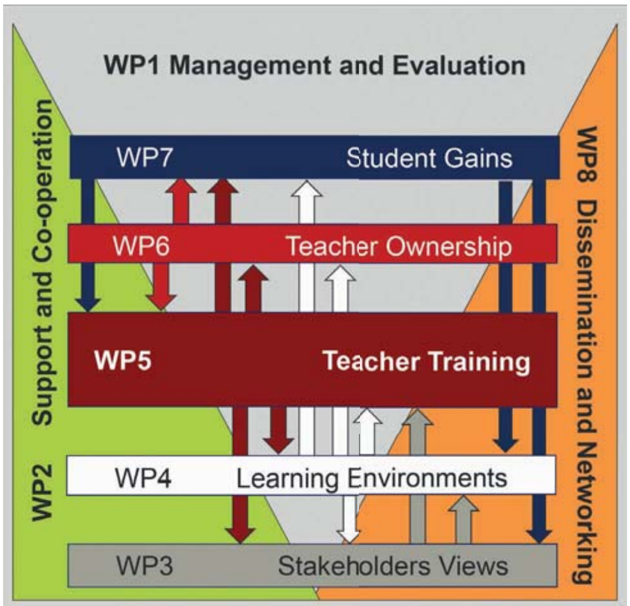


Figure 3. Interdependencies of the PROFILES project's work packages

Reflections on PROFILES

Now, after 44 month of cooperation, the colleagues of the 22 different partner institutions involved in the PROFILES project take the opportunity to reflect on the work which has been carried out so far, to share experiences, to offer insights into the project activities and to present some of the outcomes of the PROFILES project. In this section we will introduce reflections of the work package leaders and their teams looking back at the work carried out so far within the PROFILES project.

References

Bolte, C., Streller, S., Holbrook, J., Rannikmäe, M., Hofstein, A., Mamlok Naaman, R., & Rauch, F. (2012). Introduction into PROFILES – Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-*

based Science Education in Europe: Reflections from the PROFILES Project (pp. 31–42). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Bolte, C., Streller, S., Holbrook, J., Rannikmäe, M., Mamlok Naaman, R., Hofstein, A., & Rauch, F. (2011). PROFILES: Professional Reflection Oriented Focus on Inquiry-based Learning and Education through Science. *Proceedings of the European Science Educational Research Association (ESERA),* Lyon, France, September 2011. Retrieved from http://www.esera.org/media/ebook/strand5/ebook-esera2011_BOLTE_2-05.pdf (06.06.2014).

Nielsen, J., Lindner, M., Bolte, C., Galvão Couto, C., Gräber, W., Holbrook, J., Mamlok, R., Michelsen, C., Rannikmäe, M., Rocha dos Reis, P., Sybek, P., & Tsarpalis, G. (2008). Popularity and Relevance of Science Education and Scientific Literacy – The PARSEL Project in Europe. In A. Macdonald (Ed.), *Planning science instruction: From insight to learning to pedagogical practices* (pp. 193–194). Proceedings of the 9th Nordic Research Symposium on Science Education 11th – 15th June 2008 Reykjavik, Iceland.

PARSEL. (2006–2009). Retrieved from: http://www.parsel.uni-kiel.de/cms (29.07.2014).

PROFILES. (2010). Retrieved from: www.profiles-project.eu (15.04.2014).

2.2 Management and Evaluation in PROFILES

Claus Bolte & Konstanze Scheurer – Freie Universität Berlin, Germany

Within *Work package 1 (Management and Evaluation),* the PROFILES coordinator and the PROFILES Consortium created and followed a *shared strategy of cooperation and support between the partners and the European Commission*. Especially aspects of *mobilizing and coordinating financial provision* throughout the partner network were carried out with the help of the PROFILES coordinator (Claus Bolte) and his team. Frequent communication with beneficiaries and the EC administration about diverse questions regarding finances and project management was a major part of the work within Work package 1. For those who are currently planning to create a proposal for submission within the Horizon 2020 call of the European Commission, we strongly recommend calculating a reasonable amount of personal months to cover the work and efforts which are necessary for administrational tasks and duties within a project's management.

The interactive *PROFILES International website* has been developed since the beginning of the project (http://www.profiles-project.eu/). This website was improved and updated continuously by the coordinator and his staff. We want to thank Reiner Wille, who created the general structure of the PROFILES International website and the PROFILES logo, as well as Michael Albertus and Anke Ayvasky, who have been and still are taking care of updating the PROFILES International website. Regarding the PROFILES International website and its updates, the FUB team was assisted and supported by all partners, especially by the leader of WP8 (dissemination and network). The PROFILES International website served as orientation and as a template for the development of the PROFILES local websites of all consortium partners created at the beginning of the project (www.profiles-project.eu). All PROFILES websites – the international and the local ones – have been established for the virtual community of science educators, science teachers and any other stakeholders or local actors throughout Europe and beyond. The PROFILES International website was continuously updated in order to offer up-to-date information to project partners as well as to other stakeholders interested in the PROFILES project and its outcomes.

In the *dissemination section* interested colleagues can find information about the PROFILES Conferences and the PROFILES Newsletters, as well as a list of presentations and publications of PROFILES partners. The PROFILES Newsletters

A *"Log-in area"* was designed to be used by beneficiaries only as a non-public information source. Address lists, minutes and agendas of meetings, presentations from meetings, photos, deliverables and reports are available to the beneficiaries here. We would highly recommend offsetting up a "Log-in area" because it was of great value for the project members' internal communication.

In the *"Public area"*, a regularly updated news section was implemented. In the 2nd period of the project, the PROFILES International website was restructured and now features the topics "dissemination", "learning environments" and "conference 2014" in the main navigation bar.

Picture 1. PROFILES International and national websites

include reports of PROFILES partners' work and engagement, reflections of the work package leaders and other experts on central and important issues and topics of PROFILES (e.g. the realization of Teacher Continuous Professional Development Programmes (see WP5), the evaluation of the development of Teacher Ownership (see WP6), or answers to the question why it is useful to analyze Students Gains and how to do this (see WP7). All PROFILES Newsletters are provided by the leader of WP8 and his team. In the same section the three books of PROILFES can be found: the two books of invited presenters from the 1st and the 2nd PROFILES conference (Bolte, Holbrook & Rauch, 2012; Bolte & Rauch, 2014) as well as the book of PROFILES Case Studies and Best Practice Examples (Bolte, Holbrook, Mamlok-Naaman & Rauch, 2014). All of the PROFILES Books and Newsletters are available for download from this website.

All in all, especially the section "Dissemination" was and still is very much supported by the leader of WP8 and his team. Therefore, on behalf of the whole consortium we want to thank the team of the University of Klagenfurt – and especially Mira Dulle – for the work regarding the publication of the PROFILES Newsletters and for their support in publishing the three Books of PROFILES.

Picture 2. Colleagues at the PROFILES Consortium and Steering Committee Meeting in Klagenfurt, April 2013

The section *"learning environments"* offers a list of links to the local websites of PROFILES partners. There, the PROFILES partners have published their PROFILES modules (learning environments; see WP4) that they have developed so far and published in English and/or their local languages. The PROFILES learning environments (PROFILES modules) can also be downloaded for further use.

Furthermore, a publicity leaflet – the *"PROFILES flyer"* – was created by the PROFILES coordinator and his team and disseminated among the other PROFILES partners as a template. All partners adapted this template, translated it into their local language(s) and disseminated their flyers to different stakeholders and interested colleagues within their country (see WP8).

Until now, six *PROFILES Consortium and Steering Committee Meetings* have taken place, namely in Tartu/Tallinn (hosted by the UTARTU team), in Ein Gedi (hosted by the WEIZMANN team), in Klagenfurt (hosted by the UNI-KLU team), and in Porto (hosted by the UPORTO team) as well as two meetings in Berlin (hosted by the FUB team). The organization of these meetings involved a lot of effort and time. Therefore, we would like to thank the hosting partners for the work and time they invested and for their hospitality, which always had a positive impact on these successful meetings. All consortium meetings included workshops in order to make the partners familiar and support them with the tasks and objectives of the activities to be carried out within the different work packages. These face to face meetings were of significant importance. From our point of view and experiences, these meetings cannot be substituted by other approaches, such as video conference. Therefore, we – the PROFILES management team – would strongly recommend scheduling a reasonable number of face to face meetings; every six or nine month seems to be an appropriate period.

Before the consortium and steering committee meetings, the members of the *PROFILES Leaders Steering Committee* (i.e. the leaders of the eight PROFILES work packages) came together for additional face to face meetings to prepare the workshops and seminars for the PROFILES Consortium meetings as well as to negotiate and agree on the agenda for the PROFILES Steering Committee meetings, which took place in the frame of the PROFILES Consortium meetings. The FUB team would also recommend planning meetings like this, especially when a project is structured and organized like the PROFILES project. In the PROFILES project all partners are involved in all of the eight project work packages. Hence, each partner has to take care of the tasks and issues of the respective work package. As no partner can be an expert of everything, the efforts of cooperation and support are huge, but in our experience the learning effects and the positive impact of this approach on the partners' professional development was worth choosing this way of cooperation. In addition to the face to face meetings, the members of the Leaders Steering Committee discussed current issues via an enormous number of e-mails and during several telephone and skype conferences. However, from our – the FUB team's – point of view, these appointments cannot substitute the Leaders Steering Committee face to face meetings.

To the 'PROFILES Leaders Steering Committee Meetings' the coordinator invited, in accordance with the members of the PROFILES Leaders Steering Committee, the *Independent External Evaluator* for support and consultation. Periodical meetings with the Independent External Evaluator either with the coordinator or with the work package leaders are highly recommended.

In 2012, the leader of WP1 and his working group planned in cooperation with the working groups of the other work package leaders (especially with the leader of WP8) *the 1st PROFILES International Conference on Stakeholders' Views* (see Bolte, Holbrook & Rauch, 2012). This conference was organized by the FUB team and took place at the Freie Universität Berlin from 24th to 26th September 2012. More than 110 participants from all PROFILES partner countries and beyond attended this conference. This event fostered and strengthened cooperation and networking within the PROFILES project and with other European projects focusing on Science Education in general and IBSE in particular. Co-operations have been initiated on the one hand between stakeholders from all PROFILES partner countries, and on the other hand between the PROFILES Consortium and members of other EC-funded projects who have been invited to attend this conference or who attended the PROFILES conference out of their own motivation. At this conference, all participants had the opportunity to present their work and offer insights into their projects as well as to discuss the impact and problems of the implementation of innovative

IBSE approaches within Europe and beyond. Further details regarding this conference can be found in PROFILES Book # 1 (Bolte, Holbrook & Rauch, 2012).

The 2nd PROFILES International Conference on Science Education in Europe was planned also in cooperation with the PROFILES consortium as a whole and the other work package leaders. While writing this contribution, the FUB management team is currently still organizing this conference which takes place from 24th to 27th August 2014 again at Freie Universität Berlin (Germany). The management group at FUB started planning this event in summer 2013 by drafting an agenda and by other organizational measures in order to make the 2nd PROFILES Conference as successful as the previous one.

Picture 3. Appetizer for the PROFILES International Conferences

As mentioned before, the book of invited presenters from the 2nd PROFILES conference (Bolte & Rauch, 2014) will be available for download via the PROFILES International Website (www.profiles-project.eu) from mid-August (see WP8). The FUB management team would like to thank – also on behalf of the whole PROFILES consortium – all colleagues who have been actively involved in this task, especially the invited experts for their keynote contributions, the teachers from the different countries and the guests from the other EC-funded projects who took over the tasks of presenting their work and sharing their experience within the "Science Education Fair" event. But we would also like to thank the PROFILES partners who prepared posters to share their evidence based insights into their work and investigations and those who organized workshops in order to increase professional skills of the participants.

Another focus of action was on *the (first) amendment to the PROFILES Grant Agreement*. The amendment became necessary because of the non-accession of one intended partner and the request to withdraw of two other partner institutions due to changes in the partners' institutions' personal structure. Within the frame of the amendment, the PROFILES consortium invited the Karlstad University (KaU) in Sweden, the University of Copenhagen (UCPH) in Denmark and the Ilia State University (ILIAUNI) in Georgia to join the PROFILES consortium. The PROFILES consortium is honored that the colleagues and representatives of KaU, UCPH and ILIAUNI agreed to join the PROFILES consortium at this late stage and although this complex amendment procedure required a substantial amount of time and effort. However, the revised and updated documents were finally approved by the European Commission. Since 27th November 2013 the PROFILES Consortium consists of 22 partner institution from 21 different countries (see Figure 1, p. 28). Regarding the PROFILES 1st amendment but also for all the support the PROFILES consortium in general and the management team of the coordinator in particular received so far, we would really like to thank the PROFILES' Project Officers as well as the Financial Officers and all the other staff members at the EC offices involved for their help and cooperation.

References

Bolte, C., Holbrook, J., & Rauch, F. (Eds.). (2012). *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project*. Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Bolte, C., Holbrook, J., Mamlok-Naaman, R., & Rauch, F. (Eds.). (2014). *Science Teachers' Continuous Professional Development in Europe: Case Studies from the PROFILES Project*. Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Bolte, C., & Rauch, F. (Eds.). (2014). *Enhancing Inquiry-based Science Education and Teachers' Continuous Professional Development in Europe: Insights and Reflections on the PROFILES Project and other Projects funded by the European Commission*. Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

2.3 Stakeholders Involvement and Interaction in PROFILES

Claus Bolte & Theresa Schulte – Freie Universität Berlin, Germany

Within work package 3 "Stakeholders involvement and interaction", all PROFILES partners adapted the template of a *PROFILES Flyer* prepared by the leader of WP1 (FUB). They translated this template into their local language and disseminated it as a "PROFILES appetizer" among local stakeholders via mail, e-mail and the PROFILES Project's International Homepage (www.profiles-project.eu) as well as via their local PROFILES websites (see also WP1 and WP8).

In March 2011, the PROFILES partners started to solicit stakeholders' views on purposes and objectives of contemporary science teaching and learning in schools, focusing also on the impact of inquiry-based science education and on best teaching practice. For this purpose, the PROFILES consortium agreed on a shared strategy of how to conduct the collection of their stakeholders' views, how to involve them into the discussion and how to interact with the stakeholders involved. The decision how to involve as many stakeholders as possible and in a scientifically sound manner led to the *"PROFILES International Curricular Delphi Study on Science Education"*, which was carried out in each partner's country. Furthermore the PROFILES consortium agreed on the size and composition of the stakeholder sample (about 100 participants in total) and the specific sub-samples (about 25 participants per sub-sample or "stakeholder group"). The targeted sample includes stakeholders concerned with science education and with different expertise in this field. Stakeholders of four different groups were invited to participate, namely: (1) students in schools, (2) science teachers (including science education students at university, trainee science teachers, in-service science teachers, and trainee science teacher educators), (3) science educators at universities and science education researchers and (4) scientists. Detailed descriptions concerning the sample composition and the technique of a Curricular Delphi Study are provided in the 1st book of PROFILES (see Bolte, Holbrook & Rauch, 2012; especially Schulte & Bolte, 2012, pp. 42–51). This shared strategy allows for a comparison of the results received in the different countries' data collections and analyses (Schulte et al., 2014a; 2014b).

By now, 20 partners (from 19 different countries) have finished *the first round of their 'PROFILES National Curricular Delphi Studies on Science Education'* in a proper and scientifically sound manner. They sent their 1st Interim Report to the leader of WP3 for further reports and meta-analyses. In total, more than 2 700 stakeholders have been involved in the first round of the PROFILES International Curricular Delphi Study on Science Education. All in all, these achievements can be considered as a very solid basis for the two following rounds of the PROFILES Curricular Delphi Study. What is more, as the average number of involved stakeholders exceeds the targeted number of stakeholders (about 100 per partner country distributed among the four groups of stakeholders; see above). On this wide data base possibilities emerge to analyze conceptual similarities and differences regarding the terms "science education" and "scientific literacy" as they are used in the different partner countries based on an empirically sound and solid Europe-wide data source (Schulte et al., 2014a; 2014b; Gauckler, Schulte & Bolte, 2014/in this book).

Up to now, 19 PROFILES partners (in 18 different countries) finished *the second round of their*

'PROFILES National Curricular Delphi Studies on Science Education' and sent their 2nd Interim Report to the leader of WP3. More than 2 000 stakeholders in total have been involved in the second round of the PROFILES International Curricular Delphi Study on Science Education so far. The drop-out (difference of the number of participants in round 1 (N_1>2 700) and round 2 (currently: N_2>2 000) was expected because pre-post-investigations and especially longitudinal studies – such as a Curricular Delphi Study – always have to cope with a drop-out of participants.

18 partners (in 17 different countries) have finished the third round of their data collection and sent their 3rd Delphi Interim Report to the leader of WP3. Until now, more than 1 700 stakeholders have fed back their answers and assessments regarding the 3rd round questionnaire and shared their views on a desirable science education within *the third round of the (Inter-)National PROFILES Curricular Delphi Study on Science Education*.[1]

As most of the work in WP3 related to the PROFILES International Curricular Delphi Study on Science Education is completed, insightful results have been received from the different rounds of this study. These results have been reported and discussed at (inter-)national conferences on science education (e.g. at NARST 2013 in Puerto Rico, ESERA 2013 in Nicosia (Cyprus), the ICCE 2014 in Toronto (Canada), and GDCP 2012 in Hannover (Germany). First results of the national (Keinonen, Kukkonen, Schule & Bolte, 2014; Börlin & Labudde, 2014; Bolte & Schulte, 2014; Charro, Plaza & Gómez-Niño, 2014; Kapanadze & Slovinsky, 2014; Özdem & Cavas, 2014; Rundgren, Persson & Chang Rundgren, 2014; Schulte & Bolte, 2012; 2014a) as well as of the international investigations are already published (Schulte et al., 2014a; 2014b; Gauckler, Schulte & Bolte, 2014).

Within the first round, insightful statements were collected with respect to how scientifically sound aspects of desirable and modern science education in Europe can be reconstructed from the perspectives of different stakeholder groups in the partners' countries. The results of the PROFILES Curricular Delphi Studies' first rounds indicate considerable overlaps in the collective opinions in the participating countries (Schulte & Bolte, 2012; Gauckler et al., 2014). Especially the results of the national investigations served as and provided meaningful and helpful orientation for the development of learning and teaching materials (see WP4) and for the preparation of the PROFILES CPD programmes for teachers (see WP5) (Schulte & Bolte, 2014b).

Within the second round, more specific assessments by the stakeholders in the participating countries were collected and more sophisticated and reliable insights were received. Assessments were made both regarding the priority of the different aspects of desirable (inquiry-based) science education and regarding their realization in practice. In particular, the results of the second round have revealed which aspects of desirable science education are seen by the stakeholders in the participating countries as most (or less) important and relevant in order to provide educational offers such as teaching and learning materials (see WP4) and CPD for teachers (see WP5) to enhance scientific literacy in a respective country (Schulte & Bolte, 2014b). Aspects that are seen as most important include e.g. aspects related to the promotion of students' interests in science, the connection between science and everyday life and more general skills of education such as analysing and drawing conclusions, application of knowledge, critical assessment, or acting responsibly and reflectedly. Lower priorities are assigned to aspects related to the more traditional science disciplines and sub-disciplines. The practice assessments show that, in contrast to the priorities, mainly aspects of traditional curriculum framework, the traditional science disciplines (biology, chemistry and physics) and their sub-disciplines and basic scientific concepts are seen as highly present in current science education, whereas many of the highly prioritised aspects are perceived as less realized in current practice. The results therefore show which aspects of science education are realized best or (over-)emphasized and most importantly, which relevant deficiencies

[1] As the 3rd Interim reports of some partners are currently still pending, the total number of stakeholders involved in round three will increase as we receive these currently missing reports.

in educational practice are to face today and to overcome in the future. Besides this, the results of the second round also indicate common tendencies among the partner countries' science education practice and towards the need for action especially regarding aspects related to enhancing students' interests in science, the relation between science and everyday life, the implementation of IBSE and other overarching educational goals such as critical assessment, acting responsibly and reflectedly, and the application of knowledge (Schulte et al., 2014a). Taking into account the stakeholders' views and opinions with regard to the more differentiated assessments provides the opportunity to enhance the quality of learning and teaching materials developed within the PROFILES CPD programmes for teachers in a more specific manner (see WP4 and WP5).

Within the third round, further assessments by the stakeholders were collected in the partners' countries regarding "concepts of desirable science education" (Schulte & Bolte, 2014a). These concepts were identified in the second round by means of cluster analyses. The priority assessments and the estimations of the realization of the empirically based and theoretically sound concepts in practice, as well as the calculations of priority-practice-differences based on the available Delphi Interim Reports of the 3rd round, show notable overlaps among the countries. First common tendencies point towards a shortfall of the three identified concepts of desirable science education which we named as (1) "awareness of the sciences in current, social, globally relevant and occupational contexts relevant in both educational and out-of-school settings", (2) "intellectual education in interdisciplinary scientific contexts of general science-related education" and (3) "facilitation of interest in contexts of nature, everyday life and living environment" (Schulte & Bolte, 2014a). These shortfalls appear especially in the field of secondary education. The results of the 3rd round hold out the prospect of further enhancement of project activities (especially within WP4 and WP5). They build a helpful basis for practice-focused and political consulting from different stakeholder groups' perspectives. On the basis of the results of the PROFILES (Inter-)National Curricular Delphi Study on Science Education, improvement of science educational practice seems to be still a common European challenge. Further notable and scientifically grounded results of the PROFILES International Curricular Delphi Study on IBSE are expected from the final considerations and comparisons, which are currently in progress and which we will present as soon as all data analyses by the partners are complete and available.

For more than 15 years the leader of WP3 has been working on the topic of 'Curricular Delphi Studies in Science Education Research' (Bolte, 2000; 2003; 2008). During this time, no other comparable cooperative action could be found in the field of Curricular Delphi Studies which involved so many participants (experts) in a Curricular Delphi Study, nor is there any other Curricular Delphi Study carried out in a scientifically sound manner in so many countries (Häußler, Frey, Hoffmann, Rost & Spada, 1980; Häder, 2000; Burkard & Schecker, 2014). Both aspects and criteria really make the 'PROFILES (Inter-)National Curricular Delphi Study unique, in Europe and worldwide. In consequence, the leader of WP3 initiated a *meta-analysis* based on the reports of the PROFILES partners' *National Curricular Delphi Studies* we received so far. First results of analysing the findings of the PROFILES Curricular Delphi Studies' 1st and 2nd round reports are already available and will be discussed at the "2nd PROFILES International Conference on Science Education in Europe" which will take place in Berlin, 25th to 27th August 2014. A selection of findings from this meta-analysis is provided in this book (see Gauckler, et al., 2014 in this book). The meta-analysis of the partners' Delphi reports of round 3 is currently in progress.

Besides the activities concerning the PROFILES International Curricular Delphi Study, the PROFILES partners organized *National Stakeholder Meetings on Science Education* in their countries. What is more, in September 2012 the *1st PROFILES International Conference on Stakeholders Views* took place in Berlin; more than 110 stakeholders from more than 20 different countries attended this conference and shared their views on and discussed how to optimize science education practice in Europe and beyond. Throughout the conference, a strong focus was set on the implementation of inquiry-based science education and experiences with PROFILES modules (WP4) that were developed according to stakeholders' views (WP3) and teacher needs (WP4; see also Schulte et al., 2014b). More elaborate and detailed information on the discussions and insights of this conference can be found in the "Book of invited presenters of the 1st International PROFILES Conference" (Bolte, Holbrook & Rauch, 2012), which is available via the PROFILES International Homepage (www.profiles-project.eu).

References

Börlin, J., & Labudde, P. (2014). Swiss PROFILES Delphi Study: Implication for Future Developments in Science Education in Switzerland. In C. Bolte, J. Holbrook, R. Mamlok Naaman, & F. Rauch (Eds.), *Science Teachers' Continuous Professional Development in Europe: Case Studies from the PROFILES Project* (pp. 48–58). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Bolte, C. (2000). Delphi-Studie Chemie: Orakel irreleitenden Inhalts oder Orientierungshilfe zur Bewältigung von Bildungsaufgaben? In R. Brechel (Ed.), *Motivation und Interesse; Voraussetzung und Ziel des Unterrichts in Chemie und Physik. Zur Didaktik der Physik und Chemie. Probleme und Perspektiven* (pp. 229–231). Alsbach: Leuchtturm-Verlag.

Bolte, C. (2003). Konturen wünschenswerter chemiebezogener Bildung im Meinungsbild einer ausgewählten Öffentlichkeit – Methode und Konzeption der curricularen Delphi-Studie Chemie sowie Ergebnisse aus dem ersten Untersuchungsabschnitt. *Zeitschrift für Didaktik der Naturwissenschaften (ZfDN), 9*, 7–26. Kiel: IPN Kiel.

Bolte, C. (2008). A Conceptual Framework for the Enhancement of Popularity and Relevance of Science Education for Scientific Literacy, based on Stakeholders' Views by Means of a Curricular Delphi Study in Chemistry. *Science Education International, 19*(3) 331–350.

Bolte, C., Holbrook, J., & Rauch, F. (Eds.). (2012). *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project*. Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Bolte, C., & Schulte, T. (2014). Stakeholders' Views on Science Education in Europe: Method and First Insights of the PROFILES International Curricular Delphi Study on Science Education. In C. P. Constantinou, N. Papadouris, & A. Hadjigeorgiou (Eds.), *E-Book Proceedings of the ESERA 2013 Conference: Science Education Research For Evidence-based Teaching and Coherence in Learning. Part 8 (co-ed. M. Ossevoort & J. A. Nielsen)* (pp. 131–142). Nicosia, Cyprus: European Science Education Research Association. Retrieved from http://www.esera.org/media/esera2013/Claus_Bolte_19Dec2013.pdf (12.06.2014).

Burkard, U., & Schecker, H. (2014). Curriculare Delphi Studien. In D. Krüger, I. Parchmann, & H. Schecker (Eds.), Methoden in der naturwissenschaftsdidaktischen Forschung (pp. 159–168). Berlin – Heidelberg: Springer Verlag.

Charro, E., Plaza, S., & Gómez-Niño, A. (2014). Using the Delphi Technique to improve Science Education in Spain. In C. Bolte, J. Holbrook, R. Mamlok Naaman, & F. Rauch (Eds.), *Science Teachers' Continuous Professional Development in Europe: Case Studies from the PROFILES Project* (pp. 31–37). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Gauckler, M., Schulte, T., & Bolte C. (2014). Aspects of science education from a European perspective – First results from a meta-analysis of the International PROFILES Curricular Delphi Study on Science Education. In C. Bolte & F. Rauch (Eds.), *Enhancing Inquiry-based Science Education and Teachers' Continuous Professional Development in Europe: Insights and Reflections on the PROFILES Project and other Projects funded by the European Commission* (pp. 125–133). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Häder, M. (2000). *Die Delphi-Technik in den Sozialwissenschaften: Methodische Forschungen und innovative Anwendungen*. Wiesbaden: Westdt. Verl.

Häußler, P., Frey, K., Hoffmann, L., Rost, J., & Spada,

H. (1980). *Physikalische Bildung: Eine curriculare Delphi-Studie. Teil I: Verfahren und Ergebnisse*. IPN-Arbeitsbericht 41. Kiel: IPN.

Kapanadze, M., & Slovinsky, E. (2014). Stakeholders' Views on Science Education in Georgia – Curricular Delphi Study. In C. Bolte, J. Holbrook, R. Mamlok Naaman, & F. Rauch (Eds.), *Science Teachers' Continuous Professional Development in Europe: Case Studies from the PROFILES Project* (pp. 24–30). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Keinonen, T., Kukkonen, J., Schulte, T., & Bolte, C. (2014). Stakeholders' Views of Science Education: Finnish PROFILES Curricular Delphi Study – Second Round. In C. P. Constantinou, N. Papadouris, & A. Hadjigeorgiou (Eds.), *E-Book Proceedings of the ESERA 2013 Conference: Science Education Research For Evidence-based Teaching and Coherence in Learning. Part 8 (co-ed. M. Ossevoort & J. A. Nielsen)* (pp. 160–171). Nicosia, Cyprus: European Science Education Research Association. Retrieved from http://www.esera.org/media/esera2013/Tuula_Keinonen_21Dec2013.pdf (12.06.2014).

Özdem, Y., & Cavas, B. (2014). The Realization of Inquiry-based Science Education in PROFILES: Using a Delphi Study to Guide Continuous Professional Development. In C. Bolte, J. Holbrook, R. Mamlok Naaman, & F. Rauch (Eds.), *Science Teachers' Continuous Professional Development in Europe: Case Studies from the PROFILES Project* (pp. 59–69). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Rundgren, C.-J., Persson, T., & Chang Rundgren, S.-N. (2014). Comparing different Stakeholders' View on Science Education with the Science Curriculum in Sweden: Reflecting on the PROFILES 3–Stage Module. In C. Bolte, J. Holbrook, R. Mamlok-Naaman, & F. Rauch (Eds.), *Science Teachers' Continuous Professional Development in Europe: Case Studies from the PROFILES Project* (pp. 38–48). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Schulte, T., & Bolte, C. (2014a). Stakeholders' Views on Empirically based Concepts for Science Education to Enhance Scientific Literacy – Results from the Third Round of the International PROFILES Curricular Delphi Study on Science Education. In C. P. Constantinou, N. Papadouris, & A. Hadjigeorgiou (Eds.), *E-Book Proceedings of the ESERA 2013 Conference: Science Education Research For Evidence-based Teaching and Coherence in Learning. Part 8 (co-ed. M. Ossevoort & J. A. Nielsen)* (pp. 197–204). Nicosia, Cyprus: European Science Education Research Association. Retrieved from http://www.esera.org/media/esera2013/Theresa_Schulte2_19Dec2013.pdf (12.06.2014).

Schulte, T., & Bolte C. (2014b). Case Studies on Science Education based on Stakeholders' Views Obtained by Means of a National/International PROFILES Curricular Delphi Study. In C. Bolte, J. Holbrook, R. Mamlok Naaman, & F. Rauch (Eds.), *Science Teachers' Continuous Professional Development in Europe: Case Studies from the PROFILES Project* (pp. 19–23). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Schulte, T., & Bolte, C. (2012). European Stakeholders Views on Inquiry-based Science Education – Method of and Results from the International PROFILES Curricular Delphi Study on Science Education Round 1. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 42–51). Berlin: Freie Universität Berlin / Klagenfurt: Alpen-Adria-Universität Klagenfurt.

Schulte, T., Bolte, C., Keinonen, T., Gorghiu, G., Kapanadze, M., & Charro, E. (2014a). A Comparative Analysis of Stakeholders' Views on Science Education from Five Different Partner Countries – Results of the Second Round of the International PROFILES Curricular Delphi Study on Science Education. In C. P. Constantinou, N. Papadouris, & A. Hadjigeorgiou (Eds.), *E-Book Proceedings of the ESERA 2013 Conference: Science Education Research For Evidence-based Teaching and Coherence in Learning. Part 8 (co-ed. M. Ossevoort & J. A. Nielsen)* (pp. 185–196). Nicosia, Cyprus: European Science Education Research Association. Retrieved from http://www.esera.org/media/esera2013/Theresa_Schulte1_10Feb2014.pdf (12.06.2014).

Schulte, T., Georgiu, Y., Kyza, E. A., & Bolte, C. (2014b). Students' and Teachers' Perceptions of

School-based Scientific Literacy Priorities and Practice: A Cross-Cultural Comparison between Cyprus and Germany. In C. P. Constantinou, N. Papadouris, & A. Hadjigeorgiou (Eds.), *E-Book Proceedings of the ESERA 2013 Conference: Science Education Research For Evidence-based Teaching and Coherence in Learning. Part 10 (co-ed. J. Dillon & A. Redfors)* (pp. 132–140). Nicosia, Cyprus: European Science Education Research Association. Retrieved from http://www.esera.org/media/esera2013/Theresa_Schulte_19Dec2013.pdf (12.06.2014).

2.4 Establishing the PROFILES Learning Environment Considering Teacher Needs towards the Paradigm 'Education through Science'

Miia Rannikmäe & Jack Holbrook – University of Tartu, Estonia

Abstract

PROFILES initiates a learning environment for its classroom operationalisation by selecting teachers with an interest in developing motivational ways of teaching inquiry-based science education (IBSE) within an 'education through science' (ES) frame. The teaching approach is based on a PROFILES, philosophically developed, 3-stage model. This is seen as important to create an initial stage which encourages teachers to begin teaching from a student-familiar platform, sustain the initial motivation while scaffolding the science learning component (promoted through an education through science focussed, IBSE provision, as the 2nd stage of the model) thereby promoting motivational, student centred science learning through the use of PROFILES modules. The relevance of the learning is expected to be enhanced by an additional PROFILES stage (stage 3), consolidating the science ideas gained and initiating discussions related to a socio-scientific, decision-making situation (giving further meaning to the initial learning frame). This PROFILES approach is seen as more than a context-based learning, or problem based learning (PBL), environment. In fact, the intended PROFILES philosophical and operational approach is claimed to provide a unique motivational teaching environment within science lessons, yet building on that from a previous project – PARSEL.

Introduction

Work package 4 (WP4) focuses on developing the learning environment, not just within the school, but also in enabling the teachers continuous professional development CPD (developed in WP5) to function and thus guide intervention within the classroom, where PROFILES modules (developed under WP4) are tried out during the in service workshops and evaluated within WP7 (Evaluation of Students Gains). The goals for the work package 4: Learning Environments are a) to identify 'teacher needs' to form the base and hence the area to stress for the CPD, related to the PROFILES philosophy and approach (Bolte, Holbrook & Rauch, 2012; Bolte et al., 2012, pp. 31–42; Bolte et al., 2011), and b) to guide the preparation of training materials (exemplar PROFILES modules and other partner created training materials e.g. powerpoint slides, moodle programme) for use during CPD sessions, or for best practice intervention in PROFILES science teaching, for which classroom teaching modules are selected and, where necessary, adapted by teachers. Thus, within the PROFILES WP4 learning environments, the following components (aspects) can be identified: the PROFILES philosophy, the PROFILES teaching approach, CPD materials and teaching modules (both for training and classroom intervention, see Holbrook & Rannikmäe, 2012).

The PROFILES learning environment philosophy

This is linked with recognising that science and science education are not the same; producing 'little scientists' is not the sole intention for science teaching. Students need to be prepared for any kind of career choices and equipped with competences needed for the 21st century. With this in mind, the philosophy is based on 'education through science' which emphasises that learning science knowledge and concepts is important for understanding and handling socio-scientific issues within society, not just to learn fundamental science knowledge, concepts, theories and laws (Holbrook & Rannikmäe, 2007; 2012). Figure 1 illustrates the 3 stages of the PROFILES philosophical model through which student learning is initiated in a motivational manner and developed to ensure conceptual science learning which has relevance to the initial scenario. Each stage has its own role in stimulating different type of questions by students. The contextualisation phase provides students with an intrinsically motivational situation in which students have the opportunity to ask a wide range of questions, not necessarily having a scientific content and may have values oriented social viewpoints. In this stage the teacher's crucial role is to identify meaningful questions which relate to students' prior learning and which form the base for scientific learning in the next learning stage.

The decontextualisation phase is primarily linked with deriving the scientific question as the base for the student-centred scientific investigation through which new scientific knowledge and skill are development in a problem-solving situation. This phase relates directly to IBSE and is presented in an appropriately challenging format depending on whether it is seen as promoting structured, guided or open inquiry (Kask, 2009). A major challenge here is to develop teaching modules that are not simply a set of structured worksheets with little student creative involvement.

The final phase, re-contextualisation, allows students to reflect on the science gained in a societal context and pose questions that lead to decision-making and even career choices. A major learning aspect here is related to argumentation and reasoning decisions made while rebutting arguments put forward by others.

PROFILES teaching approach

Conceptualising the philosophy and gaining ownership of this is essential for implementing the PROFILES (operational) approach, which is targeted to stimulating students' intrinsic motivation by the teacher for learning science within school settings (Deci & Ryan, 1985). The teaching is initiated by means of a scenario for which students' can and also 'wish to' be involved. The scenario is not stereotyped (always of the same style or using the same teaching approach) and can be modified by the teacher, who knows students' needs, to further enhance students' intrinsic motivation. It is important there is one or more scientific questions, which drive the specific learning, either put forward by the teacher, or where feasible by the students themselves. Efforts by the teacher are directed towards ensuring that students are motivated to address the scientific question(s) by seeking the appropriate evidence (Holbrook & Rannikmäe, 2010; 2012).

Science learning, initiated by a **familiar contextual frame** of reference, linked to a need in the eyes of students.	Meeting the science learning needs by **decontextualised** scientific learning giving due attention to NOS.	Consolidation of the scientific learning through transference to the contextual frame **(recontextualised)** and promoting socio-scientific decision-making.
Stems from a social context involving science	Takes place in a science context (non-social)	Enhancing scientific literacy in a socio-scientific context

Figure 1. The Contextualisation – Decontextualisation – Recontextualisation phase model (Holbrook & Rannikmäe, 2010)

The role of the context

Within PROFILES the context plays an essential role in the initial stage. Not only does it set the scene (a scenario), but introduces elements of familiarity to students and strives to stimulate students for further science learning. The education through science philosophy recognises the importance of promoting positive attitudes and identifying initial values held by students. As indicated by Gilbert (2006), there are four different models related to context:

a) Context as the direct application of concepts
b) Context as reciprocity between concepts and applications
c) Context as provided by personal mental activity
d) Context as the social circumstances

While the first is the common standing point for the teaching of science and this may interact with the second context, the last two contexts are particularly essential within the PROFILES approach and need to identifiable within PROFILES modules, both being based on activity theory and situated learning (van Aalsvoort, 2004). This aspect is particularly important noting the poor image of science teaching, related to irrelevance, being boring, abstract in nature and difficult, as indicated in 'Science Education Now' (European Commission, 2007). In fact paying strong attention to contexts (c) and (d) can be viewed as a PROFILES innovation.

PROFILES teaching modules

To facilitate PROFILES teaching and to guide teachers in gaining self-efficacy in enacting PROFILES during the teacher invention component of the CPD and beyond, PROFILES advocates carefully designed teaching modules, compatible with, but not directly indicating, the 3-stage model (Holbrook & Rannikmäe, 2012). Such modules specifically intend that the teacher:

a) Sees the importance of stressing students' emotional interest in the situation, promoting student motivation as the key to success in meaningful science learning.
b) Recognises that science education includes cognitive learning, the gaining of a range of scientific and communication skills, personal development in terms of positive attitudes and aptitude progressions toward science learning and the development of social attributes, most noticeable teamwork skills, leadership and developing societal socio-scientific values based on a meaningful appreciation of the nature of science.
c) Ensures the time spent on the teaching/learning is in keeping with the learning needs to be developed for achieving competences related to the science curriculum. The learning acquired by students must be meaningful and sufficiently comprehensive to enable students to meet the full curriculum intentions.
d) Pays careful attention to the title of the teaching module being introduced so as to ensure it is student-friendly, sufficiently familiar, appreciated by students as personally relevant to them and does not include scientific terms that create an image of abstractness, or being difficult.

The modules are intended as a support for the teacher and thus attempt to provide guidance, while encouraging teachers to modify to suit their own emphases (Holbook & Rannikmäe, 2014). In this, the PROFILES description of work (PROFILES, 2010) indicates that a PROFILES module includes at least 4 sections. The first section provides the learning background, paying attention to the learning area intended and amplifying, in detail, the learning outcomes or competences to be developed. Section 2 is suggesting student tasks stemming from an initial, familiar yet stimulating scenario. These tasks cover the 3 PROFILES stages without distinguishing between them from a learning point of view. Section 3 is a suggested teacher guide, put forward in as much detail as appropriate to offer support for the teacher in meeting the PROFILES approach. Figure 2 gives an example of teaching scheme which can form part of the teacher guide. Section 4 relates to the important area of assessment and guides the teacher to focus on gaining feedback relates to meaningful learning geared to the competence or learning outcomes intended to be acquired by students (not just in terms of cognitive science, but covering the knowledge, skills, attitudes and values related to the module; see also WP7). A 5th section, if present, relates to background information for the teacher, giving notes, internet references, etc.

The example illustrated in Figure 2 is based on a module entitled ‘Smells – not only cosmetics?’ (http://www.lote.ee/profiles/). It outlines the teaching approach as it moves from stage to stage.

Over the three years all PROFILES partners gained ownership (for teachers’ ownership see WP6) of major components of the PROFILES environment. The type of partners’ ownership regarding the adaptation or development of PROFILES modules/ learning environments was determined by the leader of WP4 through the analyses of modules whether used for initial CPD provision and/or developed during the CPD course. Most partners used PARSEL modules as a starting point and modified those against the country needs. Where teachers under a particular partner created new modules, this was – in the opinion of the WP4 leader – an even stronger indicator of partners understanding of the PROFILES philosophy. A further indicator was where teachers were guided by partners to explicitly specify the education through science and inquiry learning related competences as learning outcomes in modules, and in about 75% cases the philosophical component ’education through science’ was well highlighted. Education through science was not emphasised in cases where partners felt their teachers were already familiar with this due to the educational system and hence more time and emphasis was needed to put on other components. Some deviations were related to the type of scenario created by teachers – as students below age 13–14 are often not capable to make socio-scientific decisions (EC, 2007), modules developed for use at lower levels often belonged to context categories (a) or (b) as indicated by Gilbert (2006). An interesting modification to socio-scientific issue based scenarios was undertaken by Bremen group – introducing a socio critical approach (Marks & Eilks, 2009).

References

Bolte, C., Holbrook, J., & Rauch, F. (Eds.). (2012). *Inquiry-based Science Education in Europe:*

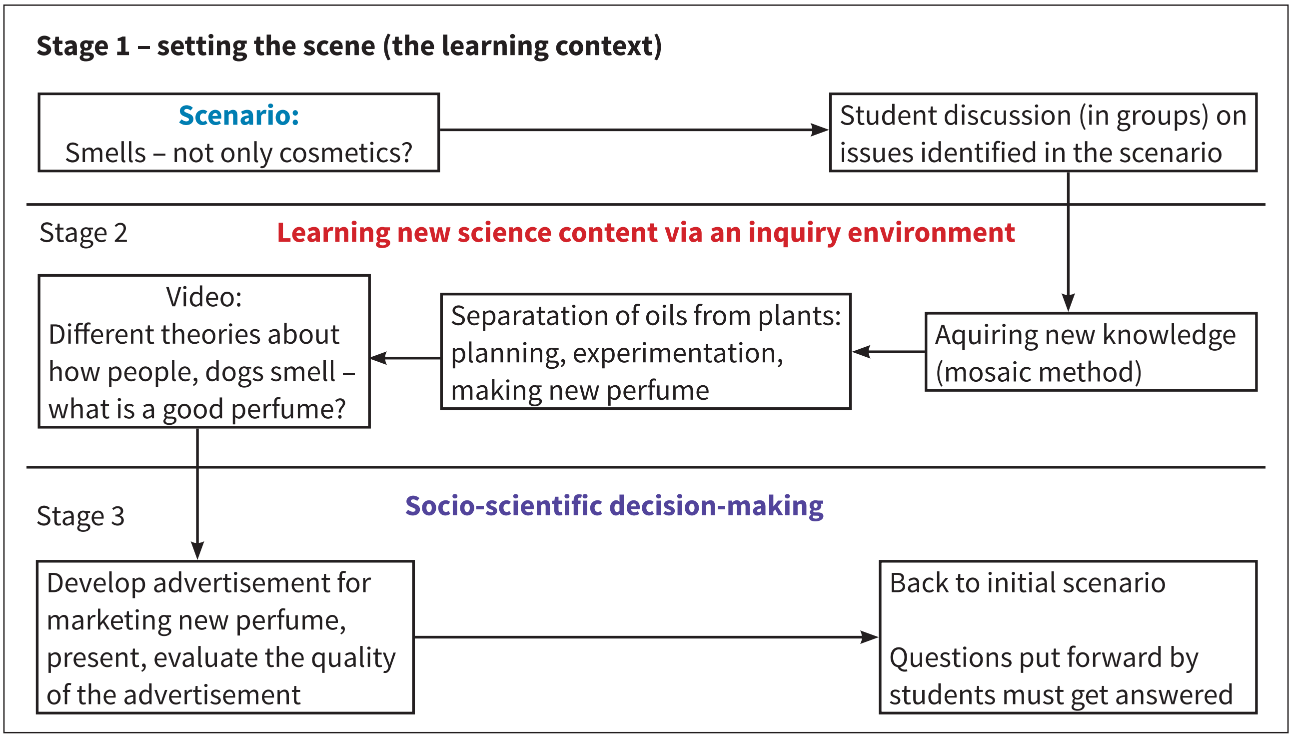


Figure 2. Example of a teaching scheme based on the 3-stage model illustrating the progress through the 3 components

Reflections from the PROFILES Project. Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria Universität Klagenfurt (Austria).

Bolte, C., Streller, S., Holbrook, J., Rannikmäe, M., Hofstein, A., Mamlok-Naaman, R., & Rauch, F. (2012). Introduction into PROFILES – Professional Reflection Oriented Focus on Inquiry-based Learning and Education through Science. In C. Bolte, J Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 31–42). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria Universität Klagenfurt (Austria).

Bolte, C., Streller, S., Holbrook, J., Rannikmäe, M., Mamlok-Naaman, R., Hofstein, A., & Rauch, F. (2011). PROFILES: Professional Reflection Oriented Focus on Inquiry-based Learning and Education through Science. *Proceedings of the European Science Educational Research Association (ESERA)*, Lyon, France, September 2011. Retrieved from: http://lsg.ucy.ac.cy/esera/e_book/base/ebook/strand5/ebook-esera2011_BOLTE_2-05.pdf (31.05.2012).

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York: Plenum.

European Commission (EC). (2007). *Science Education Now: A renewed pedagogy for the Future of Europe. Report by a High Level Group on Science Education*. Brussels: EC.

Gilbert, J. K. (2006). On the Nature of "Context" in Chemical Education. *International Journal of Science Education, 28*(9), 957–976.

Holbrook, J., & Rannikmäe, M. (2010). Contextualisation, Decontextualisation, Recontextualisation – A science teaching approach to enhance meaningful learning for scientific literacy. In I. Eilks & B. Ralle (Eds.), *Contemporary science education* (pp. 69–82). Aachen, Germany: Shaker Verlag.

Holbrook, J., & Rannikmäe, M. (2007). Nature of Science Education for Enhancing Scientific Literacy. *International Journal of Science Education, 29*(11) 1347–1362.

Holbrook, J., & Rannikmäe, M. (2012). PROFILES Modules of Best Practice. In C. Bolte, J. Holbrook & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 202–207). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität (Austria).

Kask, K. (2009). A study of science teacher development towards open inquiry teaching through an intervention programme. PhD thesis. Estonia: Tartu University Press.

Marks, R., & Eilks, I. (2009). Promoting Scientific Literacy Using a Socio-critical and Problem-Oriented Approach to Chemistry Teaching: Concept, Examples, Experiences. *International Journal of Environmental and Science Education, 4*(3), 231–245.

PROFILES. (2010). www.profiles-project.eu.

Rannikmäe, M., & Holbrook, J. (2014). Case Studies on PROFILES Learning Environments. In C. Bolte, J. Holbrook, R. Mamlok-Naaman, & F. Rauch. (Eds.), *Science Teachers' Continuous Professional Development in Europe: Case Studies from the PROFILES Project* (pp. 71–75). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität (Austria).

van Aalsvoort, J. (2004). Activity theory as a tool to address the problem of chemistry's lack of relevance in secondary school chemical education. *International Journal of Science Education, 26*(13), 1635–1651.

2.5 From the PROFILES Continuous Professional Development Programme to the Development of a Sense of Ownership

Avi Hofstein & Rachel Mamlok-Naaman – Weizmann Institute of Science, Rehovot, Israel

Abstract

In this report we summarize our reflections, experiences, and perceptions related to the development and the two leading work packages, namely, WP5& 6. Each partner coordinated two cycles of CPD. In total about 1 500 teachers participated in these two CPD cycles. The duration of each cycle (on average) was 50 hours in which 25 teachers were involved. WP5& 6 leaders were involved in guiding the partners and their professional development provider. This included CPD strategies, ideas for classroom implementation, and dealing with partners' concerns and difficulties that arose throughout each cycle. Information about the CPD was obtained via on-line questionnaires administered among the partners. In addition, information about teachers' self-efficacy and ownership related to the PROFILES project was obtained using teachers' reflections (based on essays and orally).

Introduction

One of the most important lessons that the science education milieu learned from the 1960s and 1970s, the golden age of science curricula development in the USA and in the UK, was the vital importance of appropriate dissemination and implementation procedures when teaching science. It was found, both based on research as well as on our personal experiences, that developing the curriculum does not immediately ensure success. One of the key factors regarding curriculum change is the teachers' ability to implement the curriculum in their classroom. Over a period of almost 60 years, we have learned that following the curriculum development process, which is usually short, teachers need support throughout its implementation (including adaptation and adoption).

The second lesson that we have learned is the importance of the intensive involvement of the science teachers in various components of the curricular cycle. This includes teachers' suggestions regarding the content, pedagogy (the instructional techniques to be used), and the assessment of students' achievements and progress using assessment techniques aligned with the pedagogies used. In the last 20 years, based on our experience in the 1960s and based on various reports published in the literature regarding the involvement of chemistry teachers, curriculum developers, chemistry educators, and chemists from academia in curriculum development (see, for example, the SALTERS' programmes in the UK [Bennet & Lubben, 2006], and based on various projects in Israel [e.g. Hofstein, Mamlok-Naaman & Carmeli, 1997]), have provided "bottom-up" (as opposed to "top-down") development. The bottom-up approach to the professional development of teachers was the key model used, for example, in the EU-sponsored project entitled PARSEL, conducted in several countries in Europe. Regarding the PARSEL project in Israel, Blonder, Mamlok-Naaman and Hofstein (2008, p. 298) wrote that:

> *The "bottom-up" approach helped the teachers to align their teaching with the philosophy and the teaching style of the PARSEL project. At the same time, the teachers adopted the modules to their own needs, their schools, and their students, and maintained their own professional identity. Each phase in the adaptation process increased the teacher's ownership towards the PARSEL project and its unique value aided in forming the modules before the teachers met the Israeli students.*

Thus, it is reasonable to assume that involving teachers in the process of curriculum development and its related implementation in the school system might reduce this gap in teacher participation. Learning materials resulting from such teachers' involvement have more potential to be adopted in today's schools. In general, the involvement of leading teachers in the long-term professional development and implementation of new curricula leads to effective customizations aligned with the original rationale of the developers, yet teachers can respond to the local needs, types of schools, and the unique school and its related classroom learning environments.

What are the characteristics of a long-term continuous professional development (CPD) programme?

Effective CPD should provide an opportunity for teachers to reflect on and learn about how new practices can evolve, or be modified from existing classroom practice. Teachers need to familiarize themselves with new ideas and also understand the implications for themselves as teachers and for their students in the classroom before they can adopt and implement them. Not surprisingly, it has been recognized that conventional methods of conducting CPD have usually suffered from being too short and/or only occasionally foster changes in teachers' classroom practice (Loucks-Horsley, Hewson, Love & Stiles, 1998). Based on many research studies, Loucks-Horsley et al. (1998) highlighted important features that characterize effective CPD programmes, such as the following:

- engaging teachers in collaborative long-term inquiries into teaching practices and student learning;
- introducing these long-term inquiries into problem-based contexts that consider content as central and integrating them with pedagogical issues;
- enabling teachers to approach teaching-learning issues, embedded within real classroom contexts, through reflections and discussions of each other's teaching and/or examination of students' work;
- focusing on the specific content or curriculum teachers will be implementing so that teachers will be given sufficient time to determine what and how they need to adapt the curriculum regarding their current teaching methods.

CPD models that have potential to develop teachers' sense of ownership

In their book, *Designing Professional Development for Science and Mathematics Teachers*, Loucks-Horsley et al. (1998) listed 15 specific professional development strategies. It is beyond the scope of this manuscript to list all, but it is worthwhile to mention those key strategies in which the science teachers are intensively involved: focus-group, study group, action research, curriculum development, as well as adaptation and curriculum implementation. The last two were the key strategies that were adopted for the CPD reported in this manuscript. Loucks-Horsley et al. (1998) had this to say about these strategies (p. 43):

Regarding curriculum development and adaptation, they mentioned: *creating new instructional materials and teaching strategies or tailoring existing ones to meet the learning needs of students*.

Regarding curriculum implementation, they mentioned: *learning, using, and refining the use of a particular set of instructional materials in the classroom*.

Clearly, these two CPD strategies, namely, the development of an innovation and implementing it in the chemistry classroom complement each other. Both strategies have the potential for the chemistry teachers to be intensively involved and thus they should be conducted in parallel. On the importance of implementing an innovation, Fullan (1991) suggested that the implementation phase of the curriculum cycle has probably the most significant impact on the outcomes of any educational efforts to bring about changes related to the content and its related pedagogy.

The goal of *curriculum [development] implementation* (as a CPD strategy) is to create new learning materials or instructional techniques that will be *implemented* (also a CPD strategy) in the science classroom. The *curriculum implementation* CPD strategies of the teachers involve the following aspects: They learn new science topics (CK) and their aligned pedagogies (PCK); they collaborate with peers, experts, and professional development providers; and they plan assessment strategies aligned with the content and pedagogy. In addition, during the CPD process while implementing the learning materials, the teachers are provided with opportunities for reflection on their classroom experiences. Loucks-Horsley et al. (1998) suggested that these activities have the potential to enhance the teachers' professional growth and eventually will lead to more effective classroom teaching and learning practices.

The PROFILES project: the structure of the professional development

One common theme underlying recent reports on science education is that the [orientation of the] content of school science and its related pedagogical approaches are not aligned with the interests and needs of both society and the majority of the students. Most students do not find their science classes interesting and motivating. These claims are especially valid regarding those students who, in the future, will probably not embark on a career in science or engineering, but will need science and technology personally and functionally as literate citizens. One key problem seems to be that few science programmes around the world teach how science is linked to those issues, very relevant to students' life, environment, and role as a citizen. As a result, many students are unable to participate in societal discussions about science and its related technological applications (Hofstein, Eilks & Bybee, 2011).

In the last three years, 20 institutions in Europe and Israel have been involved in developing and implementing the PROFILES (Professional Reflection Oriented Focus on Inquiry-based Learning and Education through Science) project (EU: FP7 projects on: Science & Society), which aims at making science learning more relevant to the learner. This is promoted through more meaningful and motivational science education.

While the PROFILES acronym provides a strong direction for the project (Bolte, Holbrook & Rauch, 2012), four key aspects form a major focus the type of classroom environment to be promoted through PROFILES: Making science learning more relevant (for a detailed discussion about the meaning and scope regarding relevance, see Stuckey, Hofstein, Mamlok-Naaman & Eilks, 2013).

- A student-centered approach *(student involved – Scenario introduction, Inquiry-based Learning, Socio-scientific decision-making)*
- Educating learners through ideas enhancing scientific literacy for all students (Holbrook & Rannikmäe, 2009)
- Valuing context-based science education (Bennet & Lubben, 2006)

Of major importance for the PROFILES project is that its novel approach differs greatly from teachers' previous experiences and professional enhancement; therefore, they need to reshape their own beliefs regarding science teaching and learning. This involves reconsidering core principles and issues (educational theory in PROFILES) as well as contextualizing them in developing practices and approaches (education through science ideas in PROFILES). The real challenge is when teachers return to their schools, where the ideas that were developed during the PROFILES CPD sessions, probably conducted outside the supportive climate of the teachers' meetings, are considered as an integral component of the CPD sessions. It is then that the intervention aspect of CPD is put into operation before reflection on PROFILES, and on ways to sustain the PROFILES' goals, which can serve as a further key component of the CPD programme. Details about PROFILES' goals, philosophy, and pedagogy can be found in various publications (Bolte, Holbrook & Rauch, 2012). The key goal, however, is to enhance science teachers' skills related to IBSE (inquiry-based science education), decision-making related to student-relevant science learning, and learning related to *"education through science"* (Holbrook & Rannikmäe, 2007). This is accomplished by conducting a long-term CPD initiative. Teachers within the CPD programme are supported by a carefully planned, one-year-long, CPD, aiming at supporting PROFILES ideas and consisting of four partially overlapping features: The *teacher as a learner, the teacher as a teacher,* *the teacher as a reflective practitioner,* and finally for some of the teachers who assume developing a high level of sense of ownership, the *teacher as a leader* (Hofstein & Mamlok-Naaman, 2014). The first two features are usually developed throughout the CPD programme by most teachers and having as their main focus the support of teachers in promoting students' interdisciplinary and student-centered teaching (and learning) processes. The first aims at enhancing teachers' content knowledge (CK), i.e. their scientific background. The second feature aims at promoting the teachers' PCK. This is usually based on determining the teachers' needs and expectations in areas considered important for PROFILES teaching. The 3rd feature, namely, the *teacher as a reflective practitioner*, is highly based on the teachers' classroom experiences in operationalizing PROFILES. The CPD initiative provides the teacher with opportunities to reflect on their classroom experiences; this includes pedagogical, accomplishments, concerns, and difficulties. In this capacity, the CPD participants and professional development providers interrelate to provide a dynamic and continuous platform for feedback and reflections. The participants and the CPD providers suggest ways to improve the classroom environment, for example, by discussing classroom performance, time management, and how to improve the role of the laboratory as a learning environment. The fourth feature is the development of a high-level sense of ownership regarding the philosophy and pedagogical approaches. The development of ownership is one of the most important variables related to developing leadership among the participating teachers. Fullan (1991) defined teachers' leadership as the ability of teachers to bring about a change in the educational system. In the case of PROFILES, it is suggested (e.g. Hofstein, Carmi & Ben-Zvi, 2003) that those who developed a high level of ownership can become leading teachers in the future, having the potential to disseminate PROFILES ideas (in the present and in the future) and that they need to be involved in in-service professional development initiatives and present PROFILES ideas to other teachers in the school, or in the region.

In general, we can sum-up by indicating that most participating PROFILES partners were successful in providing their teachers with the necessary experiences to develop the CK and the PCK for effective development and implementation of PROFILES learning materials and pedagogy. In addition we have evidence based on partners reports that many teachers (in the partners countries) developed self-efficacy related to the implementation of PROFILES modules and that about 10–15% of the teachers even demonstrated those behaviors that characterize leading teachers.

References

Bennett, J., & Lubben, F. (2006). Context-based chemistry: The Salters approach. *International Journal of Science Education, 28*(9), 999–1015.

Blonder, R., Mamlok-Naaman, R., & Hofstein, A. (2008). Increasing Science Teachers ownership through the adaptation of the PARSEL modules: A "bottom-up" approach. *Science Education International, 19*(3), 285–301.

Bolte, C., Holbrook, J., & Rauch, F. (Eds.). (2012). *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project*. Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Fullan, M. (1991). *The new meaning of educational change*. New York: Teachers College Press, Teachers College, Columbia University.

Hofstein, A., & Mamlok-Naaman, R. (2014). Case Studies on PROFILES Teacher Training (CPD) and Ownership. In C. Bolte, J. Holbrook, R. Mamlok-Naaman, & F. Rauch (Eds.), *Science Teachers' Continuous Professional Development in Europe: Case Studies from the PROFILES Project* (pp. 161–164). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Hofstein, A., Eilks, I., & Bybee, R. (2011). Societal issues and their importance for contemporary science education: a pedagogical justification and the state of the art in Israel, Germany and the USA. *International Journal of Science and Mathematics Education, 9*(2011), 1459–1483.

Hofstein, A., Mamlok, R., & Carmeli, M. (1997). Science teachers as curriculum developers of science and technology for all. *Science Education International, 8*(1), 26–29.

Hofstein, A., Carmi, M., & Ben-Zvi, R. (2003). The development of leadership among chemistry teachers in Israel. *International Journal of Science and Mathematics Education, 1*, 34–65.

Holbrook, J., & Rannikmäe, M. (2007). Nature of Science Education for Enhancing Scientific Literacy. *International Journal of Science Education, 29*(11), 1347–1362.

Holbrook, J., & Rannikmäe, M. (2009). The meaning of scientific literacy. *International Journal of Science and Environmental Education, 4*, 275–288.

Loucks-Horsley, S., Stiles, K. E., & Love, N., (1998). *Designing professional development for teachers of science and mathematics*. Thousand Oaks, CA: Corwin.

Stuckey, M., Hofstein, A., Mamlok-Naaman, R., & Eilks, I. (2013). The meaning of 'relevance' in science education and its implications for the science curriculum. *Studies in Science Education, 49*(1), 1–34. doi:10.1080/03057267.2013.802463.

2.6 Evaluating Students Gains in PROFILES

Claus Bolte – Freie Universität Berlin, Germany

Introduction

As PROFILES takes the slogan "Education through Science" seriously, the PROFILES partners are interested in finding out how students benefit if they participate in PROFILES science lessons. For this reason, within Work package 7 (WP7: "Students' Gains") the partners agreed to investigate the impact of PROFILES type learning environments (the "PROFILES modules", see WP4) in the frame of the PROFILES interventions carried out within the PROFILES CPD programmes (see WP5). In order to find out how PROFILES oriented science teaching impacts students' motivation to learn science, the partners decided to use the "Instrument for Analyzing the 'Motivational Learning Environment' (MoLE)" in the context of their PROFILES interventions. The overarching question the PROFILES partners seek to answer is: *How do students assess the motivational learning environment in PROFILES science lessons?*

Some remarks about the theoretical background of the PROFILES students' gains analyses

The partners try to answer this question by evaluating motivational aspects (variables) such as the students' satisfaction with their science lessons and other important perceptions regarding their science lessons, namely: the comprehensibility of the topics and contents taught, opportunities to participate in the science lessons, the relevance of the topics and the orientation on the 'pure' scientific concepts, the cooperation of the class as a whole and their own willingness to participate in the lessons (see Figure 1).

Especially the aspect of students' satisfaction is expected to be most important when evaluating students' benefits, because students who are individually more satisfied with their science lessons and their science learning have more (intrinsic) motivation to learn science (Bolte, Streller & Hofstein, 2013; Bolte & Streller, 2011; Bolte, 2006). Therefore, if students show a high (or higher) level of satisfaction regarding their science education (e.g. within a PROFILES best practice implementation), then we can conclude that they are on a high (or even higher) level of intrinsic motivation. Especially if we follow a pre-post data collection design, asking the students before and immediately after the 'PROFILES intervention', we can further conclude that the effects the analyses may reveal were caused by the modules adapted or developed in the PROFILES CPD courses (see WP4) and/or by the PROFILES teaching approaches with which the PROFILES teachers became familiar through the CPD programmes (see WP5) and which

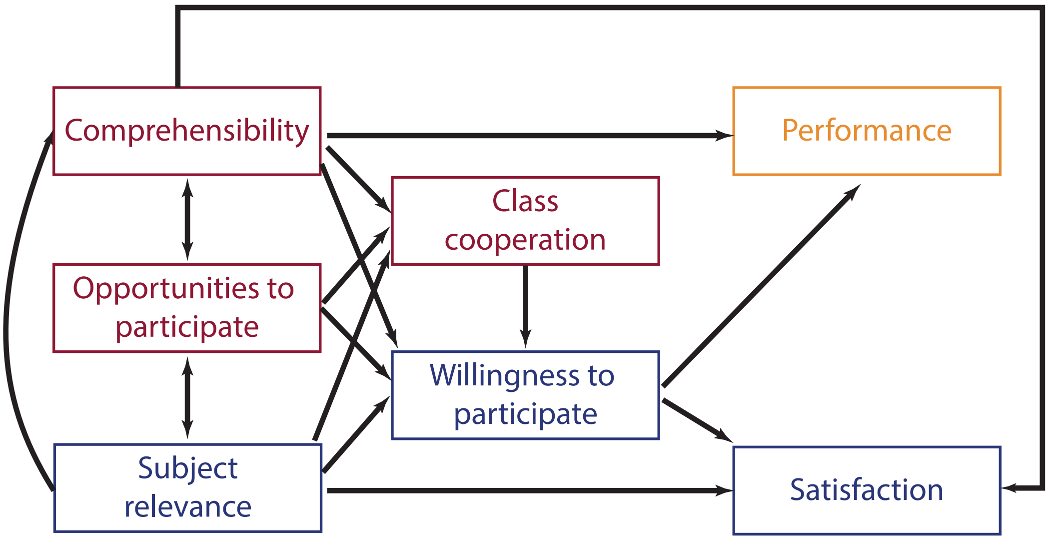


Figure 1. Theoretically based and empirically sound model regarding the impact of the different motivational aspects (MoLE variables) on students' (intrinsic) motivation to learn science

they hopefully used in their classroom intervention (see Figure 1).

Therefore, evaluating the effectiveness of the PROFILES project in general, and the impact of the PROFILES intervention – based on the PROFILES CPD programmes and/or the PROFILES type modules – in particular on the participating students' gains is one major task and target of PROFILES and the work within WP7 "Evaluating students gains".

Looking back and reflecting on the work carried out so far in Work package 7

In the 1st period of the project, different instruments for the evaluation of student gains were introduced to the partners at the 1st and 2nd PROFILES consortium meeting by the leader of the WP7 and his team members, for example: the "Instrument for Analyzing the 'Motivational Learning Environment' (MoLE)" (Bolte, 2006; Bolte & Streller, 2011); the "Self-to-Prototype-Matching Questionnaires (StoP)" and the "Developmental Task Questionnaires" (Albertus, Bolte & Bertels, 2012) as well as the "Inquiry Qualification Questionnaire (IQ2)" (Erb & Bolte, 2011).

At the 2nd PROFILES consortium meeting, the PROFILES steering committee confirmed their previous agreement to concentrate on one specific instrument, namely the "MoLE Instrument". Besides this, the consortium further decided to use at least two MoLE questionnaire versions (the MoLE REAL and the MoLE IDEAL version) and to follow a shared strategy of conducting the MoLE questionnaires either in a pre-post-test data collection (before and after a PROFILES classroom intervention) or by following a treatment-control-group design (comparing the MoLE assessments of PROFILES and non-PROFILES classes). As a next step, all PROFILES partners translated the (at least two) different MoLE questionnaire versions into their local language.

In the academic year 2011/2012, the PROFILES partners started to collect data in order to analyze the students' gains in the PROFILES classes. By now (until the end of the academic year 2013/14) nearly all partners involved in WP7 were able to collect a reasonable amount of MoLE data within the 1st and the 2nd (and in most of the cases also the 3rd) term of their PROFILES CPD programmes and were thus able to feed back a solid data source for their in-depth MoLE analyses.

In the first PROFILES CPD term (and the classroom intervention combined with this), approximately 9 000 PROFILES students (in more than 400 classes taught by more than 300 PROFILES teachers) have been involved in the PROFILES students' gains data collection. In the second PROFILES CPD and classroom intervention term, the number of students involved in the PROFILES students' gains analyses increased (as expected): Until September 2013, more than 13 000 PROFILES students in total (of more than 700 classes taught by approximately 600 PROFILES teachers) have been involved in this investigation. Until now (end of July 2014), 19 776 students fed back how they perceived their PROFILES lessons.

As mentioned above, those partners who have not reached the agreed number of participating students or classes[1] yet promised to realize a further round of data collection in order to finally reach the agreed threshold. Besides this, because of their positive experiences, some partners mentioned their interest and willingness in continuing their students' gains investigation within their current PROFILES activities although they had already achieved the agreed number of students' data.

First experiences and 'preview results'

Overall, in the frame of the PROFILES project and its CPD programme(s), the PROFILES partners and their teachers experienced the value and usefulness of the MoLE instrument, the economic data collection and the enlightening findings from the data analyses. Both designs, either as a pre-post or a treatment-control-group investigation, were assessed as helpful and illustrative for gaining insights into the motivational atmosphere of (PROFILES) science lessons.

Regarding the analyses of the data the PROFILES teachers collected, it can be stated that the students' (intrinsic) motivation to learn science increased while they were taught by means of PROFILES type modules and/or by the PROFILES IBSE oriented approaches (see for example: the working group of the University of Eastern Finland, the colleagues of the University College Cork (Ireland), the members of the FUB group and others). From our experiences and by focusing on (preliminary) reports offered by some PROFILES partners (e.g. Georgiou et al., 2014; Geoghegan & Kennedy, 2013; Schneider & Bolte, 2014; Trna & Trna, 2014) the leader of WP7 can conclude that using the MoLE instrument and following the agreed design of the data collection offer scientifically sound and interesting insights into the effectiveness and impact of the PROFILES project in general and the use of PROFILES teaching and learning modules and approaches in particular. As far as we are able to assess at the moment, the leader of WP7 and his team members have reasonable grounds for assuming that the PROFILES CPD programmes, the modules adapted or developed and finally implemented in the classrooms in combination with the PROFILES teaching approaches show an empirically and evidence based impact on the enhancement of students' (intrinsic) motivation to learn science the 'PROFILES way'. As this assumption is mainly based on the results concerning the enhancement of the students' satisfaction with the science lessons in their science classes and because in the reports mentioned above we found significant increases regarding the students' assessments of the relevance of topics they have been taught and dealt with in the PROFILES lessons, we can further assume that students really benefit from PROFILES based science education (see Figure 1) and from the PROFILES 'Education through Science' philosophy.

The adaptation and translation of the questionnaire versions led – as far as the leader of WP7 is able to asses at this stage – to objective, reliable and valid as well as interesting and scientifically sound findings (see Bolte, 2006). The reports the leader of WP7 received so far point out that PROFILES based teaching has a positive impact on students' (intrinsic) motivation to learn science. Therefore, we can be optimistic that at the end of the project we are allowed to conclude that PROFILES really supports the enhancement of students' scientific literacy.

References

Albertus, M., Bolte, C., & Bertels, N. (2012). Analyzing the Relevance of Science Education from Students' Perspectives regarding Developmental Tasks, Self and Prototype Attitudes and Motivation. In C. Bolte, J., Holbrook, & F. Rauch,

[1] Approximately 1 000 students (of approximately 50 PROFILES classes) per partner are intended to be involved in the PROFILES students' gains investigations.

(Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project*. (pp. 75–78). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria Universität Klagenfurt (Austria).

Bolte, C., & Streller, S. (2011). Evaluating Student Gains in the PROFILES Project. *Proceedings of the European Science Educational Research Association (ESERA)*, Lyon, France, September 2011. Retrieved from: http://lsg.ucy.ac.cy/esera/e_book/base/ebook/strand5/ebook-esera2011_BOLTE_1-05.pdf (31.05.2012)

Bolte, C. (2006). As Good as It Gets: The MoLE-Intrument for the Evaluation of Science Instruction. *Proceedings of the Annual Meeting of the National Association for the Research on Science Education (NARST)*, San Francisco, USA, April 2006.

Bolte, C. & Schneider, V. (2014). Chemistry in Projects (ChiP) – An Evidence-based Continuous Professional Development Programme and its Evaluation Regarding Teacher Ownership and Students Gains. In C. Bolte, J. Holbrook, R. Mamlok Naaman, & F. Rauch (Eds.), *Science Teachers' Continuous Professional Development in Europe: Case Studies from the PROFILES Project* (pp. 220–230). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Bolte, C., Streller, S., & Hofstein, A. (2013). How to motivate students and raise their interest in chemistry education. In I. Eilks & A. Hofstein (Eds.), *Teaching chemistry – a studybook* (pp. 67–95). Rotterdam (The Netherland): Sense Publishers.

Erb, M., & C. Bolte (2011). Investigating students' strengths and weaknesses in the area "scientific inquiry". *Proceedings of the Annual Meeting of the National Association for the Research on Science Teaching (NARST)*, Orlando, USA, April 2011.

Geoghegan R., & Kennedy, D. (2013). *Analysis of questionnaires to assess the 'Motivational Learning Environment' (MoLE) of upper secondary level students in Ireland – A report by the UCC/ICASE partners for PROFILES WP7.* Department of Education Cork: University College Cork (July 2013 – unpublished).

Georgiou, Y., Kyza, E. A., Demetra Paraskeva-Hadjichambi, D., Kofina-Michael, Z., Hadjistyllis, A., & Miliotis, G. (2014). PROFILES – The Case of Cyprus: The Impact of a Participatory Design-model of Inquiry-based Learning Environments on Student Motivation. In C. Bolte & F. Rauch, (Eds.), *Enhancing Inquiry-based Science Teachers' Continuous Professional Development in Europe: Insights and Reflections on the PROFILES Project and other Projects funded by the European Commission* (pp. 91–94). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Georgiou, Y., & Kyza, E. A. (2014). "Can You Listen to My Voice?" Including a Student Voice in the Design of a Chemistry Module Aiming to Increase Students' Learning and Motivation. In C. Bolte, J. Holbrook, R. Mamlok Naaman, & F. Rauch (Eds.), *Science Teachers' Continuous Professional Development in Europe: Case Studies from the PROFILES Project* (pp. 94–102). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Metljak, M., Glažar, S.A., Juriševič, M., Pavlin, J., Slapničar, M., Vogrinc, J., & Devetak, I. (2014). Three Years of PROFILES Experience in SLOVENIA: Networking, Teacher Professional Development and Student Gains. In C. Bolte & F. Rauch (Eds.), *Enhancing Inquiry-based Science Education and Teachers' Continuous Professional Development in Europe: Insights and Reflections on the PROFILES Project and other Projects funded by the European Commission* (pp. 177–184). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Trna, J. & Trnova, E. (2014). Motivational Content in PROFILES Modules – Experiences by the Czech PROFILES Partners. *PROFILES Newsletter* Vol.6, pp. 6–9.

Walan, S., & Chang Rundgren, S.-N. (2014). Students' responses to a PROFILES 3-step teaching module. In C. Bolte & F. Rauch (Eds.), *Enhancing Inquiry-based Science Education and Teachers' Continuous Professional Development in Europe: Insights and Reflections on the PROFILES Project and other Projects funded by the European Commission* (pp. 193–197). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

2.7 PROFILES Networks and Dissemination

Franz Rauch & Mira Dulle – Alpen-Adria-Universität Klagenfurt, Austria

Abstract

The keynote offers reflective insights into the activities of the PROFILES partners within work package 8, focussing on the dissemination of project materials, experiences and results, as well as the establishment of teacher networks. Beside the dissemination via local partner websites, project flyers and the publication of six newsletters, three PROFILES books are produced with contributions from the two PROFILES conferences as well as case studies from project partners. Furthermore, the PROFILES partners are very active in presenting the project at various international and national conferences and publishing their investigations and experiences in journals. In order to enhance the dissemination effect and to ensure the continuance of the PROFILES philosophy after the projects' end, a constantly growing PROFILES teacher networks are established in the partner countries, including approx. 9 000 teachers and 1 350 educational institutions.

Dissemination activities

PROFILES intends to impact on the availability of evidence-based best practice materials and the related reflective in-service training. At an early stage, all 22 PROFILES partners set up a local *website* which are updated regularly. Furthermore, central information, publications and announcements can be found on the international PROFILES website, hosted by the Freie Universität Berlin (http://www.profiles-project.eu/). Via these website news and information about the project (i.e. project outcomes, teaching materials, posters, research results, presentations, local activities and meetings and further materials) are disseminated.

In six PROFILES *newsletters*, in English as well as translated in the project partners' languages, the project news and outcomes were spread via local, national and international networks. Both approaches, the website and the newsletters, offer a successful medium to connect the local level of the PROFILES project with the international activities. Furthermore, the project partners distributed approx. 16 000 PROFILES *flyers* (approx. 6 000 printed and 10 000 digital flyers).

Beside these electronic means of dissemination, the project partners published their experiences and reflections in three PROFILES *books*:

- *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (Bolte, Holbrook & Rauch, 2012)
  This book provides an insight into the PROFILES project, its aims and objectives as well as about some of the activities initiated by PROFILES partner institutions. In particular, the book gives a picture of experiences colleagues underwent within the first period of the project's lifespan and insights into special issues and tasks PROFILES promotes to foster cooperation and support on a large scale in Europe as well beyond European borders.
- *Science Teachers' Continuous Professional Development in Europe. Case Studies from the PROFILES Project* (Bolte, Holbrook, Mamlok-Naaman & Rauch, 2014)
  This book includes 53 different articles by PROFILES teachers and partners in which they offer insights into, and overviews of, their activities within the PROFILES project through case study approaches and field reports. These case studies examine the actual teaching/learning situation by soliciting and processing as much data as possible from different sources.
- *Enhancing Inquiry-based Science Education and Teachers' Continuous Professional Development in Europe: Insights and Reflections on the PROFILES Project and other*

Projects funded by the European Commission (Bolte & Rauch, 2014).

This current book includes 69 contributions to be presented at the 2nd PROFILES conference on enhancing Scientific Literacy (Berlin, Germany, 25–27 August 2014). The six sections correspond to the four formats of the presentations during the conference and include also other projects funded by the EC in the FP6 or FP7 programme.

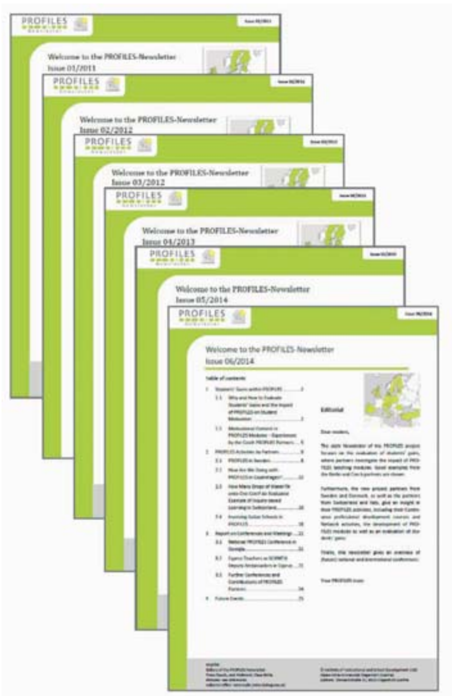


Figure 1: The six PROFILES Newsletters

Figure 2: The three PROFILES books

The PROFILES partners actively *presented* the PROFILES philosophy and their experiences at various international and national conferences, as well as at the two international *PROFILES Conferences* held 2012 and 2014 in Berlin, Germany. Accordingly, they *published* investigations and reflections in journals at local, European and international levels. Two special issues on PROFILES were published by ICASE (Science Education International) and the Faculty of Education of the University of Ljubljana (CEPS journal). An actual list of these PROFILES presentations and publications can be found on the PROFILES website mentioned above.

PROFILES networks

Another objective of PROFILES in general and WP8 in particular is the establishment of a PROFILES teachers' network, operating on a local, regional, national or Europe-wide scale. Although the initial situation differs in every partner country, data from a questionnaire study shows that partners build on already existing structures (Rauch & Dulle, 2012; Rauch, Dulle, Namsone & Gorghiu, 2014). Nevertheless, the conceptualizations are in line with general trends. Castells (2000) conceptualizes his notion of 'network' as a highly dynamic, open system consisting of nodes and flows. In the wake of these general social trends and structural transformation, networks in educational contexts have also become increasingly attractive in educational systems. Ideally, networks are conceived as an interface and an effective means of pooling competencies and resources (Posch, 1995; OECD, 2003). As intermediate structures (Czerwanski, Hameyer & Rolff, 2002), they manage autonomy and interdependent structures and processes, and try to explore new paths in learning and cooperation between individuals and institutions (Rauch, 2013).

The progress of the networking activities in the partner countries shows that from the beginning of the project in 2010, until 2014, all partners are able to significantly increase the number of teachers and formal educational institutions involved in their networking processes. The interim results of an ongoing evaluation show that, by 2014, PROFILES networks (in connection with other Science education networks) include approximately 9 000 teachers and approximately 1 350 educational institutions in all PROFILES partner countries. Furthermore, ten PROFILES partners involve approximately 30 non-educational institutions in total.

The following articles give a deeper insight into the structure and activities of PROFILES networks. These are: the workshop contribution from Rauch, Gorghiu G., Dulle and Gorghiu L. (see chapter 3.1 in this book), the poster contributions from Rauch, Dulle, Römer and Wenzl (see chapter 4.1) and Metljak et al. (see chapter 4.22), as well as the section on PROFILES networking and dissemination, in the second PROFILES book (Rauch & Dulle, 2014, pp. 245–250).

Outlook

Looking to the future, it is envisaged that the *lead teachers* (Hofstein, Mamlok-Naaman, Katchevitch, Rauch & Namsone, 2012) operating within every PROFILES network, as well as the activities and vital co-operations with other stakeholders and networks, can support a sustainable and dynamic continuity of the PROFILES networks even after the official end of the PROFILES project.

References

Bolte, C., & Rauch, F. (Eds.). (2014). *Enhancing Inquiry-based Science Education and Teachers' Continuous Professional Development in Europe: Insights and reflections on the PROFILES Project and other Projects funded by the European Commission*. Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria). 978-3-9816683-1-5

Bolte, C., Holbrook, J., Mamlok-Naaman, R., & Rauch, F. (Eds.). (2014). *Science Teachers' Continuous Professional Development in Europe. Case Studies from the PROFILES Project*. Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria). ISBN: 978-3-9816683-0-8

Bolte, C., Holbrook, J., & Rauch, F. (Eds.). (2012). *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project*. Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria). ISBN 978-3-00-039403-4

Castells, M. (2000). *The Rise of the Network Society* (The Information Age: Economy, Society and Culture, Vol.1.) (2nd Ed.). Oxford: Blackwell Publishers.

Czerwanski, A., Hameyer, U., & Rolff, H.-G. (2002). Schulentwicklung im Netzwerk – Ergebnisse einer empirischen Nutzenanalyse von zwei Schulnetzwerken. In H.-G. Rolff, K.-O. Bauer, K. Klemm, & H. Pfeiffer (Eds.), *Jahrbuch der Schulentwicklung* (pp. 99–130). München, Germany: Juventa.

Hofstein, A., Mamlok-Naaman, R., Katchevitch, D., Rauch, F., & Namsone, D. (2012). Teachers' ownership: What is it and how is it developed? In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 56–58). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Holbrook, J. (2014). Editorial. *Science Education International. 25*(2), 130–132. Retrieved from: http://www.icaseonline.net/seiweb/index.php?option=com_content&view=article&id=107&Itemid=63 (11.08.2014).

Holbrook, J., & Devetak, I. (2014). Editorial. *CEPS Journal. 4*(1), 5–8. Retrieved from: http://www.cepsj.si/doku.php?id=en:volumes:2014-vol4-no1 (11.08.2014).

OECD. (Ed.). (2003). *Schooling for Tomorrow. Networks of Innovation*. Paris: OECD.

Posch, P. (1995). Professional Development in Environmental Education: Networking and Infrastructure. In OECD (Ed.), *Environmental Learning for the 21st Century* (pp. 47–64). Paris: OECD.

Rauch, F. (2013). Regional networks in education: a case study of an Austrian project. *Cambridge Journal of Education, 43*(3), 313–324.

Rauch, F., & Dulle, M. (2014). Case studies on PROFILES networking and dissemination. In C. Bolte, J. Holbrook, R. Mamlok-Naaman, & F. Rauch (Eds.), *Science Teachers' Continuous Professional Development in Europe. Case Studies from the PROFILES Project* (pp. 245–250). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Rauch, F., & Dulle, M. (2012). How to Involve Stakeholders in IBSE Networks. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 59–67). Berlin: Freie

Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).
Rauch, F., Dulle, M., Namsone, D., & Gorghiu, G. (2014). PROFILES Networks: Three International Examples. *Science Education International, 25*(2), 97–114.

3 WORKSHOP CONTRIBUTIONS ON VARIOUS PROFILES TOPICS

3.1 Networks in Science Education

Franz Rauch & Mira Dulle – Alpen-Adria-Universität Klagenfurt, Austria
Gabriel Gorghiu & Laura Monica Gorghiu – Valahia University of Targoviste, Romania

Abstract

PROFILES is based on 'teacher partnerships' aiming to implement existing, exemplary context-led, IBSE-focused science teaching modules (Bolte et al., 2012). As such, PROFILES recognises the importance, not only of dissemination of developments for the benefit of science teachers across Europe and even worldwide, but also the need for interaction through a well-researched and effective networking system at the school, local, national and European/worldwide levels. The theoretical and practical approach of PROFILES networking is presented with particular reference to Austria and Romania. Evaluative findings show, among other things, that regional networks carry out creative projects and thereby tend to raise the attractiveness of science lessons in cross-curricular co-operations, which involve several school types and use innovative methods. The networks offer goal-oriented exchange processes among teachers, which support the professional development of teachers. Participants get an insight into the concept of networking in science education and discuss and share their professional experiences.

Within PROFILES, teacher networks are established in every partner country to:

(a) enhance the dissemination of the project philosophy (IBSE and Education through Science) (Bolte et al., 2012; Holbrook & Rannikmäe, 2012), results of the Curricular Delphi Study on Stakeholders views (Schulte & Bolte, 2012) and student's gains (Albertus, Bolte & Bertels, 2012) and products (teaching materials, books, Newsletters etc. see also: http://www.profiles-project.eu/Dissemination/index.html)
(b) establish a sustainable structure of mutual learning and exchange with the potential to continue after the project has finished.

Based on the conception that networks are "intermediate" structures (Czerwanski, Hameyer & Rolff, 2002; OECD, 2003; Berkemeyer, Bos, Manitius & Müthing, 2008), they can support instructional and school development (Veugelers & O'Hair, 2005; Berkemayer, Kuper, Manitius & Müthing, 2009). Networks can be distinguished with regard to their complexity, from networks at schools to inter-school networks and networks at local, regional, national and international levels (Altrichter, Rauch & Rieß, 2010). PROFILES Networks include all of these types, although the school and inter-school networks are the most frequent.

The workshop provides an insight into the establishment of PROFILES networks that include (by April 2013) approx. 4.000 teachers and 1.300 educational institutions across all 21 partner countries (Rauch & Dulle, 2014). The main audience of this workshop are practitioners and teachers who can reflect on the meaning of networks in their own daily work and identify quality criteria for networks in general. Two examples of PROFILES networks in Austria and Romania are presented in more detail.

Educational networks in Austria are already well established for several years. The nation-wide 'IMST' (Innovations Make Schools Top) project aims at improving instruction in mathematics, science, IT, German language and related subjects. To put innovative instructional projects into practice, IMST supports regional networks in all nine Austrian provinces, and three thematic networks which operate at the national level. To some extent, they fill a gap caused by a lack of subject didactic centres in higher education throughout Austria and provide research-based, didactic professional development for teachers. The IMST Regional Network of Vienna acts as a basis for the Austrian PROFILES Network by providing initial coordination and the contact to the teachers. Covering approx. 50 teachers, the Austrian PROFILES Network is structured as a community of practice (Wenger, 1998), a regular working group, characterized by cooperation and reflection (Rauch & Dulle, 2014). The PROFILES community meets several times per semester to develop PROFILES modules and reflect on their implementation in class (for a detailed description of the Austrian PROFILES Network see chapter 4.1 on page 87 in this book: The PROFILES Network in Austria). Out of this group, 11 teachers are very active and work intensively and independently. These 11 teachers function as so called *lead teachers* (Hofstein, Katevich, Mamlok-Naaman, Rauch & Namsone, 2012), spearheading the professional development of additional teachers at pre- and in-service levels, initiating workshops for key stakeholders and extending the PROFILES network. In this way, the PROFILES ideas are disseminated. *"Our teachers multiply what they develop, because they bring it to their own schools"* (Coordinator of the Austrian PROFILES network).

In Romania, within the frame of PROFILES, a collaborative science teachers' network has been established, in order to raise the research interest and provide new teaching approaches in the field of science, to offer a frame for active cooperation between teachers, and to promote the exchange of ideas and materials by disseminating best practices, seminars, workshops etc. The networking activities have been strongly linked to the development and outcomes of the national accredited teacher training/continuous professional development programme called "*PROFILES – Education through Science*", but also to the results of PROFILES modules implementations in classrooms by non-PROFILES teachers. At present, the engine of the Romanian network is based on *lead teachers* who graduated the PROFILES CPD programme, but also on a consistent *Community of Practice* – developed in more than two years – who play an important role in the extension of the PROFILES Network at the national level (Gorghiu & Gorghiu, 2014). An illustration of the Romanian PROFILES network is shown in Figure 2.

Figure 1. Reflection on the PROFILES modules developed by Austrian teachers

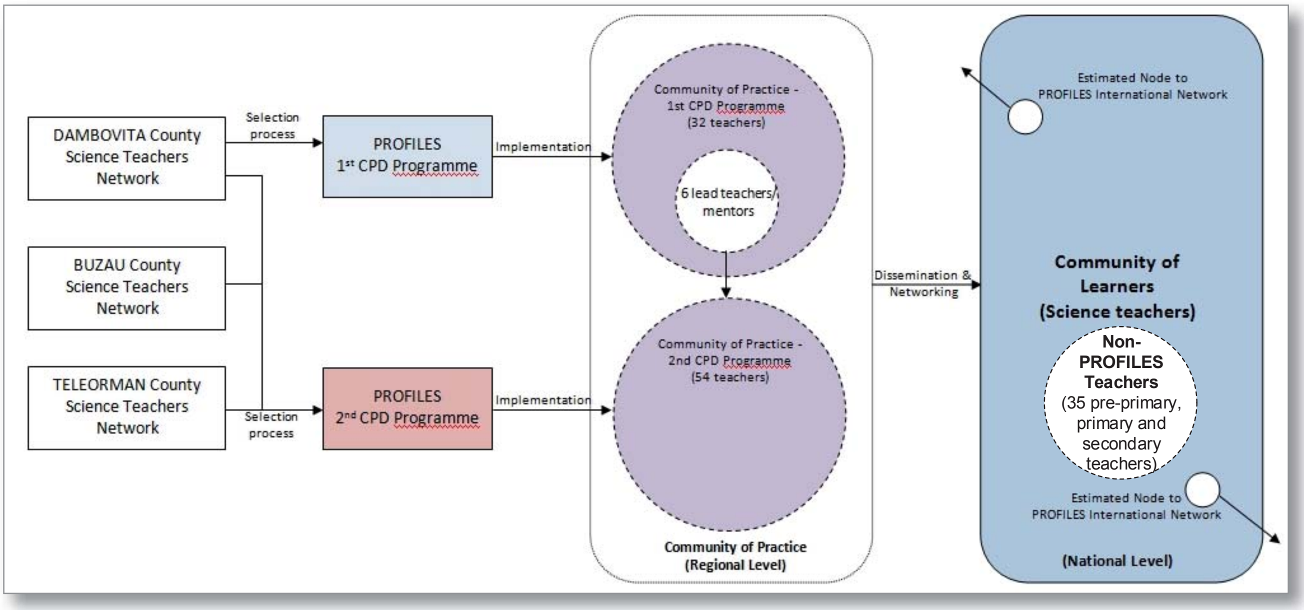


Figure 2. The actual Romanian PROFILES network

At present, the Romanian PROFILES network has three major centres (in the locations where the accredited CPD programme was provided), with extensions at regional level (another three centres) and with an important potential for being extended at national level. The whole process of networking started at school level (2012). In 2013, the network recorded 69 lower and upper secondary schools, and it is expected to include more than 100 schools by the end of 2014.

After giving an insight into how PROFILES networks operate, the question arises how to maintain these networks, how can networks be anchored sustainably in the educational sector of a country? The following recommendations intent to maintain dynamics and innovation in networks through:

- Mutual intention and goals
- Trust orientation
- Voluntary participation
- Principle of Exchange (win-win relationship)
- Steering platform
- Evaluation and accompanying research
- Face-to-face-meetings and electronic communication
- Response to current needs and developments

Nevertheless, it is also recognised that it is important to keep a balance between continuity and renewal regarding the content, processes and persons within the network (Rauch & Ziener, 2014).

During the workshop participants are asked to share PROFILES artefacts (ideas, modules, results of implementations, best practices, etc.), with the goal to nurture further developments in the countries of the participants.

References

Albertus, M., Bolte, C., & Bertels, N. (2012). Analyzing the Relevance of Science Education from Students' Perspectives regarding Developmental Tasks, Self and Prototype Attitudes and Motivation. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 75–78). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria). Retrieved from: http://ius.uni-klu.ac.at/misc/profiles/files/Profiles%20Book%202012_10.pdf (01.05.2014).

Altrichter, H., Rauch, F., & Rieß, G. (2010). Netzwerkbildung in der österreichischen Schullandschaft. In N. Berkemeyer, W. Bos, & H. Kuper (Eds.), *Schulreform durch Vernetzung. Interdisziplinäre Betrachtungen* (pp. 193–212). Münster: Waxmann.

Berkemeyer, N., Kuper, H., Manitius, V., & Müthing, K. (Eds.). (2009). *Schulische Vernetzung. Eine*

Übersicht zu aktuellen Netzwerkprojekten. Münster: Waxmann.

Berkemeyer, N., Bos, W., Manitius, V., & Müthing, K. (Eds.). (2008). *Unterrichtsentwicklung in Netzwerken. Konzeptionen, Befunde, Perspektiven*. Münster: Waxmann.

Bolte, C., Streller, S., Holbrook, J., Rannikmäe, M., Hofstein, A., Mamlok Naaman, R., & Rauch, F. (2012). Introduction into PROFILES – Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 31–42). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria). Retrieved from: http://ius.uni-klu.ac.at/misc/profiles/files/Profiles%20Book%202012_10.pdf (01.05.2014).

Czerwanski, A., Hameyer, U., & Rolff, H.-G. (2002). Schulentwicklung im Netzwerk – Ergebnisse einer empirischen Nutzenanalyse von zwei Schulnetzwerken. In H.-G. Rolff, K.-O. Bauer, K. Klemm, & H. Pfeiffer (Eds.), *Jahrbuch der Schulentwicklung* (pp. 99–130). München: Juventa.

Gorghiu, G., & Gorghiu, L. M. (2014). Analysing the Relationship between the Effectiveness of the PROFILES Continuing Professional Development Programme and the Dissemination/Networking Process. In C. Bolte, J. Holbrook, A. Hofstein, & F. Rauch, (Eds.), *Science Teachers' Continuous Professional Development in Europe. Case Studies from the PROFILES Project* (pp. 267–277). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Hofstein, A., Katevich, D., Mamlok-Naaman, R., Rauch. F., & Namsone, D. (2012). Teachers' Ownership: What is it and how is it developed? In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 56–58). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria). Retrieved from: http://ius.uni-klu.ac.at/misc/profiles/files/Profiles%20Book%202012_10.pdf (01.05.2014).

Holbrook, J., & Rannikmäe, M. (2012). Innovative inquiry-based Science Learning Environments in the framework of PROFILES. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 52–55). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria). Retrieved from: http://ius.uni-klu.ac.at/misc/profiles/files/Profiles%20Book%202012_10.pdf (01.05.2014).

IMST. https://www.imst.ac.at/ (15.04.2014).

OECD (Eds.). (2003). *Schooling for Tomorrow. Networks of Innovation*. Paris: OECD.

PROFILES. (2010). www.profiles-project.eu (15.04.2014).

Rauch, F., & Dulle, M. (2014). Science Education Networks in Austria – The Case of the Viennese PROFILES Network. In C. Bolte, J. Holbrook, A. Hofstein, & F. Rauch (Eds.), *Science Teachers' Continuous Professional Development in Europe. Case Studies from the PROFILES Project* (pp. 260–266). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Rauch, F., & Dulle, M. (2012). How to Involve Stakeholders in IBSE Networks. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 95–67). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria). Retrieved from: http://ius.uni-klu.ac.at/misc/profiles/files/Profiles%20Book%202012_10.pdf (01.05.2014).

Rauch, F., & Scherz, H. (2009). Regionale Netzwerke im Projekt IMST: Theoretisches Konzept und bisherige Erfahrungen am Beispiel des Netzwerks in der Steiermark. In K. Krainer, B. Hanfstingl, & S. Zehetmeier (Eds.), *Fragen zur Schule – Antworten aus Theorie und Praxis – Ergebnisse aus dem Projekt IMST* (pp. 273–286). Innsbruck: Studien Verlag.

Rauch, F. (2013). Regional networks in education: a case study of an Austrian project. *Cambridge Journal of Education*, *43*(3), 313–324.

Rauch, F., & Ziener, K. (2014). *Netzwerke im Bildungsbereich. Expertise im Auftrag des BMUKK*. Alpen-Adria-Universität Klagenfurt – Institut für Unterrichts- und Schulentwicklung.

Schulte, T., & Bolte, C. (2012). European Stakeholders

Views on Inquiry Based Science Education – Method of and Results from the International PROFILES Curricular Delphi Study on Science Education Round 1. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 42–51). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria). Retrieved from: http://ius.uni-klu.ac.at/misc/profiles/files/Profiles%20Book%202012_10.pdf (01.05.2014).

Veugelers, W., & O'Hair, M.J. (Eds.). (2005). *Network Learning for Educational Change*. New York: Open University Press.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge, U.K.; New York, N.Y.: Cambridge University Press.

3.2 Digital Games and Augmented Reality Applications for Learning in Science

Eleni A. Kyza & Yiannis Georgiou – Cyprus University of Technology, Cyprus

Introduction

During the last years there has been an explosion in the number of children and adolescents playing digital games or employing mobile handheld technologies, such as smart phones (Cabiria, 2012; Dunleavy, Dede & Mitchell, 2009). In contrast to this rapid expansion of interest in mobile and game-based technologies, secondary students' interest in learning science remained low, since science education appeared to have failed to engage their interest to learn science (Eurydice network, 2011). Osborne (2007) indicated that *"school science needs to find a mechanism of presenting the major stories that science has to tell in a readily understood form"* (p. 109). At a time of continued dissatisfaction with the state of science education, there is a widespread assumption that the emergence of educational digital games and Augmented Reality (AR) applications are not only aligned with the interests of learners today but most of all, they have the potential to respond to the calls for enabling students' active learning (National Research Council [NRC], 2011).

Digital games and inquiry-based science learning

Given the appeal of digital games to youth today, there is no wonder that researchers have supported that they can be an effective medium for motivating student engagement and participation in learning (Blumberg & Fisch, 2013; Gee, 2008; Martinez-Garza, Clark & Nelson, 2013). According to Martinez-Garza et al. (2013), digital games attend to issues of play, engagement and enjoyment, include rules, and are based on achieving goals for which they are rewarded. Gee (2008) describes digital games as goal-directed, problem-solving spaces, which can produce deep learning while also fostering collaboration and productive discussions about shared experiences. Despite their potential, there are few research studies on the contribution of digital games to domain-specific learning (Hwang & Wu, 2012). At the same time, a study by the European Schoolnet (Kearney, 2011) indicates that games are hardly used in schools around Europe.

Martinez-Garza et al. (2013) analyzed existing research, on the use of digital games in science education, against the science education reform goals set by the US National Research Council. Similar to claims stated earlier in this paper, they concluded that there was evidence that digital games could support, among others, students' conceptual understanding, student motivation and the development of positive attitudes towards science, as well as foster the development of inquiry and argumentation skills. At the same time, they also indicated that the key component, which determined the effectiveness of a digital game on learning, was its design and the possibilities that it afforded and not merely the fact that a game was being employed.

AR applications and inquiry-based science learning

Learning environments employing AR technologies, such as location-based AR applications, have been assumed to facilitate learning science through inquiry (Cheng & Tsai, 2013), and as a result, have received increased attention in recent years. Considering that inquiry is the main approach adopted by scientists to discover new knowledge about the physical world around us, it has been argued that inquiry-based learning creates opportunities that can motivate students and can allow them to become more active learners, who systematically attempted to understand the physical world around them (Eurydice network, 2011; NRC, 2012). Central to this approach is that students should be immersed in an investigative process that situates the learning content in an authentic context (Barab, Sadler, Heiselt, Hickey & Zuiker, 2010).

While virtual worlds seek to replace the reality, AR applications attempt to supplement it, by blending the real world with digital elements (Klopfer, 2008). This augmentation of reality is achieved by placing learners in a physical context which allows them to interact with digital information augmenting the physical environment through mobile and context-aware technologies (Dunleavy et al., 2009). Due to this potential, it is been widely argued that AR technologies can support inquiry-based learning, through facilitating students' explorations of the physical world surrounding them.

Types of AR applications

Currently, there are three main types of AR games and applications: (a) Location-aware, (b) Vision-based and (c) AR-based participatory simulations.

Location-aware AR applications usually unfold within specific real-world locations and employ mobile technologies equipped with Global Positioning Systems (GPS) to augment the users' experience by integrating additional digital media (Squire & Jan, 2007). According to Dunleavy et al. (2009) *"this type of mediated immersion infuses digital resources throughout the real world, augmenting students' experiences and interactions"* (p. 8). On the other hand, vision-based AR applications provide learners with multi-modal information, which is activated when the camera embedded in their mobile device is turned on an object (Dunleavy & Dede, 2014). Finally, in the genre of participatory simulations AR applications, learners become participants in unique, life-sized simulations that are facilitated by small wearable computers (Colella, 2000).

Affordances of AR applications facilitating learning in science

Educational AR applications have been assumed to support learning in science education through (a) facilitating the process of scientific inquiry, (b) their potential for situated learning in science, and (c) by immersing students in learning.

Cabiria (2012) highlighted, for instance, the role of AR tools in inquiry-based learning, explaining that AR applications could facilitate students in exploring objects and locations in these blended spaces according to their learning needs. Similarly, Rosenbaum et al. (2007) highlighted the authenticity derived from such AR learning environments, explaining how the affordances of mobile devices could be used to support inquiry-based activities, in which students interacted with each other and with the real environment around them. In addition, a growing body of research has argued that AR applications opened up new possibilities for situating and contextualizing inquiry-based science learning, since they provided students with several opportunities for inquiring into scientific issues with the aid of virtual information in a real world, or with real phenomena, thus allowing young learners to step outside the classroom to work in outdoor sites of educational interest (Cheng & Tsai, 2013; NRC, 2011). Finally, several researchers have argued that employing augmented reality applications, such as AR gaming woven with learning, could result in immersive learning opportunities, due to the affordances of moving throughout real-world locations, collecting authentic field data which were place-dependent, interviewing game-based characters and collaboratively investigating problem-based scenarios (e.g. Dede, 2009; Dunleavy, Klopfer, 2008).

However, despite the potential of augmented reality for learning, Cheng and Tsai (2013) have concluded in a recent review effort, that research regarding AR-aided science learning is still in its infancy. Similarly, Dunleavy et al. (2009) have highlighted that researchers should not view AR technologies as a panacea or a plague, indicating the need for further investigation in order to successfully appropriate these new technologies in the learning context.

The workshop

This workshop focuses on digital games and augmented reality technologies as two different types of cutting-edge technologies which, even though they bear promise for supporting learning in science, remain largely untapped. During the workshop we will present the rationale for using such technologies in science learning and provide examples from different domains, connecting back to the PROFILES approach for inquiry-based learning. Hands-on activities include the opportunity to explore examples of digital games for learning in science, and the use of augmented reality applications to support learning about the natural world around us. The workshop aims to familiarize participants with the potential of these technologies and provide opportunities for productive discussions about the integration of these technologies in school curricula.

References

Barab, S. A., Sadler, T. D., Heiselt, C., Hickey, D., & Zuiker, S. (2010). Erratum to: Relating narrative, inquiry, and inscriptions: Supporting consequential play. *Journal of Science Education and Technology, 19*(4), 387–407.

Blumberg, F. C., & Fisch, S. M. (2013). Introduction: Digital Games as a Context for Cognitive Development, Learning, and Developmental Research. *New Directions for Child and Adolescent Development, 2013*(139), 1–9. doi: 10.1002/cad.20026

Cabiria, J. (2012). Augmenting engagement: Augmented reality in education. In C. Wankel & P. Blessinger (Eds.), *Increasing student engagement and retention using immersive interfaces: Virtual worlds, gaming, and simulation (cutting-edge technologies in higher education, volume 6)* (pp. 225–251). New York: Emerald Group Publishing Limited.

Cheng, K.-H., & Tsai, C.-C. (2013). Affordances of augmented reality in science learning: Suggestions for future research. *Journal of Science Education and Technology, 22*(4), 449–462.

Colella, V. (2000). Participatory simulations: Building collaborative understanding through immersive dynamic modeling. *Journal of the Learning Sciences, 9*(4), 471–500.

Dunleavy, M., Dede, C., & Mitchell, R. (2009). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. *Journal of Science Education and Technology, 18*(1), 7–22.

Dunleavy, M., & Dede, C. (2014). Augmented reality teaching and learning. In J. M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (Eds.), *Handbook of research for educational communications and technology (4th ed.)*. New York: Springer.

Eurydice network. (2011). *Science in Europe: National policies, practices and research*. Brussels: Education, Audiovisual and Culture Executive Agency.

Gee, J. P. (2008). Learning and games. In K. Salen (Ed.), *The ecology of games: Connecting youth, games, and learning* (pp. 21–40). Cambridge, MA: The John D. and Catherine T. MacArthur Foundation Series on Digital Media and Learning. The MIT Press.

Hwang, G.-J., & Wu, P.-H. (2012). Advancements and trends in digital game-based learning research: a review of publications in selected journals from 2001 to 2010. *British Journal of Educational Technology, 43*(1), E6–E10. doi: 10.1111/j.1467-8535.2011.01242.x

Kearney, C. (2011). *European Schoolnet1's Games in Schools Study: The Current State of Play in European Schools and the Game Ahead*. doi: 10.4018/978-1-60960-495-0.ch003

Klopfer, E. (2008). *Augmented learning: Research and design of mobile educational games*. Cambridge, MA: MIT Press.

Martinez-Garza, M., Clark, D. B., & Nelson, B. C. (2013). Digital games and the US National Research Council's science proficiency goals. *Studies in Science Education, 49*(2), 170–208. doi: 10.1080/03057267.2013.839372

National Research Council [NRC]. (2011). *Learning science through computer games and simulations*. Washington, DC: The National Academies Press.

Osborne, J. (2007). Engaging young people with science: Thoughts about future direction of science education. In C. Linder, L. Östman, & P. Wickman (Eds.), *Promoting scientific literacy: Science education research in transition* (pp. 105–112). Uppsala: Geotryckeriet.

Squire, K. D., & Jan, M. (2007). Mad city mystery: Developing scientific argumentation skills with a place-based augmented reality game on handheld computers. *Journal of Science Education and Technology, 16*(1), 5–29.

3.3 Scenarios – A Motivational Approach Towards Inquiry-based Learning

Anu Hartikainen-Ahia, Kari Sormunen, Ilpo Jäppinen & Sirpa Kärkkäinen – University of Eastern Finland, Finland

Abstract

Scenarios, the first stage of the PROFILES model, have an important role in starting the learning process. Scenarios need to arouse students' intrinsic motivation and encourage students towards finding out about the problem, or issue presented in the scenario. This leads to the Inquiry Stage, the second phase of the PROFILES teaching approach. We analyse over 20 scenarios created by the Finnish PROFILES teachers and develop an evaluation tool based on their content, context, possible relevance to students, how they involve students reflecting on their prior knowledge, and how the scenarios arouse students' desire for inquiry. With the tool, science teachers and CPD providers can plan and evaluate effectiveness and relevance of scenarios for the teaching of modules.

Introduction

The instructional innovation of PROFILES is the so called 'Three Stage Model' (TSM), which aims to arouse students' intrinsic motivation, to offer a meaningful inquiry-based learning environment and to allow the use of the science learning within socio-scientific issues (Bolte et al., 2011). The TSM consists of three stages: 1) Scenario, 2) Inquiry, and 3) Decision-making. In this article, we concentrate on the first stage, and analyse the kinds of scenarios the Finnish PROFILES teachers have created and used in their classrooms. Based on the analysis we present an evaluation tool for scenarios.

Scenarios

The Scenario Stage of the TSM is expected to arouse students' *interest and intrinsic motivation*, undertaken in a student-familiar, *socio-scientific context* (see Figure 1). An intention is to *involve students in committing to activities* that relate to better understanding of the issue – an issue seen by students as relevant to their lives, not simply relevant to the curriculum – and worthy of greater appreciation. In facilitating the move to the Inquiry Stage, the initial interest and motivation forms a key launching platform for the intended science learning. It seeks to draw students' attention to thinking about deficiencies in their desire to undertake a meaningful discussion, related to the scenario: i.e. *reflection* upon their prior knowledge and sharing their conceptions and views with peers. This all facilitates the posing of the *scientific question*, or questions intended for investigation (Bolte et al., 2011).

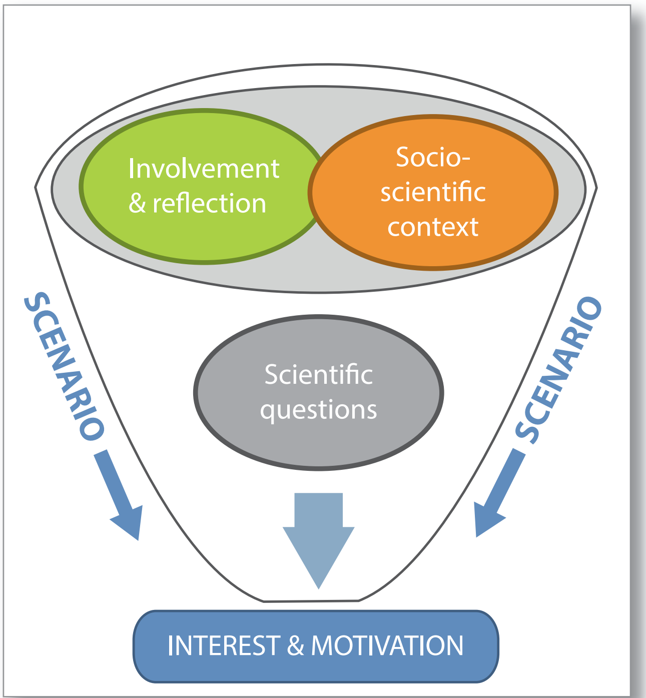


Figure 1. The main components and the aim of PROFILES scenarios

The scenarios, within the PROFILES philosophy, are described as a means to present a surprising phenomenon in nature, or of students' everyday life, or socio-scientific issues (Bolte et al., 2011). In other words, we could use real-life examples and relate materials to everyday applications, drawing cases from, e.g. current newsworthy issues and local cases (Rannikmäe, Teppo & Holbrook, 2010). When the context of a scenario is carefully chosen and the scientific ideas are embedded in it, the actual science component of the learning can begin after the science learning is de-contextualized from the initial context and when inquiry-based approach can then be applied (Bolte et al., 2011).

Towards an evaluation tool

We analysed the kind of scenarios the Finnish PROFILES teachers created and used in their science classrooms, which followed the 3-stage model. Altogether, there were 30 teachers who participated in the PROFILES programme, 21 in the first round (2011–2012) and nine during the second round (2012–2013). Almost all of them started with the existing teaching modules, originating from the PARSEL project (www.parsel.org), or those created by the CDP providers at the University of Eastern Finland (UEF). In this presentation, however, we were interested in those scenarios that the teachers created by themselves.

We went through all modules that the Finnish teachers reported to be planned and implemented. Most of them were applications, based on either the PARSEL modules, or those produced by the CDP providers at the UEF, but there were also 24 original modules, created by the teachers themselves. Most of them (18) were related to physics, three to chemistry, two to biology and one to earth science; two of them were implemented at the primary level (classes 3–6), 12 in the lower secondary (7–9) and 10 in the upper secondary (10–12).

As stated above, we concentrated merely on the scenarios, but we also paid attention to the Inquiry and Decision-making Stages in the modules in order to analyse the nature and the use of the scenario, because they are interconnected. For instance, it was essential to know what kind of inquiries were planned to take place after the Scenario Stage, or if the scenario sets down a context for meaningful decision-making at the end of the teaching module.

Our analysis was based on the method of content analysis (see e.g. Roth, 2005). The leading focus points were the component and aims of the scenarios (Figure 1): socio-scientific scenario and its relevance and meaning for students, students' involvement and activating their prior knowledge, and students' desire for new scientific knowledge. We called these the dimensions in our tool (see Table 1).

Dimensions in the tool

Relevance of the scenario

First, when we analysed the scenarios according to relevance and meaningfulness for the students, we found that we needed to pay attention to the title, the nature of the scenarios' curricular content, socio-scientific context and how a scenario was introduced to students, i.e. introductory approach; these were the so called sub-dimensions with regard to the relevance dimension in our tool. Almost all the titles of scenarios involved issues of everyday life, cf. *importance*, and some of them were in a form of *an appropriate question*. A few titles also included descriptions of working methods and learning content.

The planned modules were mostly related to only one curricular subject, although there were a variety of physics scenarios that addressed interdisciplinary issues. These *interdisciplinary modules* were all linked to sustainable development and the problem-solving required knowledge from several subjects. We called this sub-dimension as the nature of the content.

With regard to the socio-scientific context, we found that scenarios had authentic, or imaginary situations that were linked to students' everyday life; so, they included *an everyday issue. These local, national or global issues* were applied with the authentic socio-scientific scenarios.

The issues of everyday life were developed through popular events, or phenomena associated with the youth sub-culture, such as the Big Brother TV programme or celebrities.

The most popular introductory approaches through scenarios were discussion and reading *activities*; nevertheless some usage of pictures, role play, field practice and note-taking could also be identified from the scenarios. The *material* given to students was usually an authentic, or imaginary framed story about the situation or phenomenon in the form of news, or an article.

Activation of students' prior knowledge

Secondly, when analysing how the scenarios were planned to involve students to reflect on their prior knowledge, we found two kinds of approaches: students were led to think and *reflect on their prior knowledge either individually or collectively*.

Dimension	Sub-dimension	Aspects of sub-dimensions
Relevance of the scenario	Title	importance of the issue
		appropriate question(s)
	Nature of content	interdisciplinary
	Socio-scientific context	everyday issue
		local / national / global context
	Introducing approach	motivating method
		materials in an interesting format
Activation of students' prior knowledge	Openness	open problem
	Reflection	individual
		collaborative
Desire for inquiry	Guiding questions	one or a few questions
	Potential solutions	several potential solutions

Table 1. The tool for evaluating a scenario

In some cases, the individual reflection took place before discussing the topic in smaller groups, or within the whole class.

The *questions stimulating the reflection* of prior knowledge were *open* in 21 out of 24 scenarios, so students could think and form their own research questions. These scenarios had one or two *issues,* whereas three scenarios had too many questions and thus restricting students to recipe-like studying. The problems with these scenarios were the questions that discouraged thinking and problem-solving, leading to a contradiction with inquiry-based learning.

Desire for inquiry

Thirdly, we were interested in how the scenarios were planned to arouse *students' desire for* new scientific knowledge i.e. *inquiry*. We found that the socio-scientific issue of a scenario could stimulate students' actions through including a few, or several *guiding questions*. Furthermore, we paid attention to the nature of *potential solutions* to the issue that the scenario posed. Most scenarios had issues with multiple solutions, but a few scenarios were designed in such a manner that students had no choices to make. The scenarios with multiple solutions can be considered to be in line with the PROFILES philosophy, because meaningful decision-making was achievable.

Discussion

Generally, the Finnish PROFILES teachers created scenarios that aimed at collaborative learning through reflecting on prior knowledge. In addition, the scenarios had a few questions that stimulated students to be actively involved in class. The issues presented in the scenario had multiple solutions, in most cases, but clearly there were difficulties with making the scenario relevant and meaningful to students. Motivational headlining and linking the scenario with everyday life or local socio-scientific issues were also challenges to the teachers. Marks and Eilks (2009) highlighted that socio-scientific issues increased students' motivation if they included authenticity, relevance, open-endedness with respect to social questioning, being openly discussable in a public forum and having a clear-cut relationship to science and technology. It is also important that socio-scientific issues not only served as a motivating context for science learning, but also improved students' argumentation and decision-making abilities. Our wish was that the evaluation tool developed on the analysis of the teachers' original scenarios would help science teachers and CPD providers in creating motivational and relevant scenarios for science teaching and learning.

References

Bolte, C., Steller, S., Holbrook, J., Rannikmäe, M., Hofstein, A., Mamlok-Naaman, R., & Rauch, F. (2011). Introduction into the PROFILES Project and Its Philosophy. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES project* (pp. 31–42). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Marks, R., & Eilks, I. (2009). Promoting scientific literacy using a socio-critical and problem oriented approach to chemistry teaching: concept, examples, experiences. *International Journal of Science and Environmental Education, 4*, 131–145.

Rannikmäe, M., Teppo, M., & Holbrook, J. (2010). Popularity and Relevance of Science Education Literacy: Using a context-based Approach. *Science Education International, 21*, 116–125.

Roth, W.-M. (2005). *Doing qualitative research. Praxis of methods*. Rotterdam: Sense Publisher.

3.4 Once Upon a Time… Fairy Tales in Science Lessons

Sabine Streller – Freie Universität Berlin, Germany

Abstract

Fairy tales are used as a starting point for inquiry-based learning in the four modules "Once upon a time…" developed by a group of teachers during the PROFILES CPD. Many fairy tales include interesting aspects that can be useful for science education. For example, density as a property of substances can be put in a new context with the king's daughter playing with a ball made of gold in the fairy tale "The Frog Prince". All modules that the group developed provide differentiated learning opportunities. Based on fairy tales, they all focus on discussing children's research questions in forms of cooperative learning. This way, scientific methods are learned and improved. Four fairy tales by the Brothers Grimm and H.-C. Andersen turned out to be particularly adequate for the topic "everyday substances". In the workshop we will give insights into the materials and the experiences the teachers had with the implementation. In addition, we will provide opportunities to try out fairytale-like experiments.

Background: Learning science and the idea of "Once upon a time"

Planning science lessons is a challenge for many teachers. Competence and creativity are needed to plan science lessons which fulfill the high standards for scientific literacy oriented lessons. In many countries the standards and performance expectations for children of grade four, five and six cover quite ambitious scientific methods e.g. observing phenomena, describing and comparing things and situations, making measurements, planning and carrying out investigations, conducting investigations collaboratively, and developing and using models (e.g. Finnish National Board of Education 2004; GDSU 2003; NGSS 2013). The task for teachers is besides the teaching of scientific methods and contents to find a children-oriented context. Particularly for children who start to learn about sciences it is of special importance to have a connection to their everyday life, because in the first years of science education the teachers have a big influence on the motivation to learn science later on (Streller, 2009; Streller & Bolte, 2011; Bolte, Streller & Hofstein, 2013).

A group of science teachers has risen to these challenges during the PROFILES CPD and created four modules for grade five and six with an emphasis on the content "everyday substances" and on scientific methods (Streller & Bolte, 2012). The teachers of the PROFILES CPD group "ProNawi" chose the context "fairy tales" as the joining frame for the modules. This context offers the possibility to transfer the modules to different cultures – fairy tales and legends are part of cultural heritage everywhere. What is more, fairy tales present sciences from an unusual perspective, which is familiar to the children but unexpected to students. While classic interdisciplinary education usually connects "neighboring" disciplines, the modules presented in the workshop incorporate very different fields and therefore cross not only subject boundaries, but also creative boundaries.

Objectives and contents of the modules "Once upon a time"

The teachers, coming from different schools, developed the modules together in the monthly CDP-meetings (Streller & Bolte, 2012) and implemented the resulting lesson plans in their own classes. After that they reflected on the implementation together in the next CPD-meeting and started to change and optimize the lesson plans. The modules that are proposed can be easily expanded in content and method, which makes the modules and the developed material flexible in use and adaptable to other learning groups.

The aim of "Once upon a time…" is to engage students in the topic "everyday substances", which is typical for elementary science education, from a new, unusual perspective. Fairy tales, stories and fables are on the one hand popular with children and on the other hand full of scientific aspects. Four fairy tales by the Brothers Grimm and Hans-Christian Andersen were selected as particularly adequate for the topic "everyday substances", but there are certainly more. Based on these fairy tales which build the starting point of the inquiry process (scenario), the teachers designed the modules.

All of the modules and the corresponding material are directed at children of ages 10–12 of every type of school and learning stage.

Each module focuses on a different scientific content in the context of different fairy tales. The modules and objectives are:

Hansel and Gretel – Focus: Substance Properties
Students discover substance properties with the model "witch's cottage" by simulating different influences on the house in the forest. This lesson is suitable to introduce the whole topic "everyday substances".

The Frog Prince – Focus: Density
Students discover density as a property of substances by comparing materials with a model based on the phenomenon "king's daughter playing with a golden ball" and understand the concept of density through generalization. This example can also be used to introduce or consolidate a simple particle model of matter.

The Emperor's New Clothes – Focus: Thermal conductivity
Students discover thermal conductivity as a property of substances by experimenting with isolation. At the end of this module the students are able to conclude that the substance with the best isolation properties is the worst heat conductor.

Module	Experiments and student activities	Scientific methods
Hansel and Gretel Focus: Substance Properties	Examining of the influence of weather on building materials used for the witch's cottage in the fairy tale and for houses today	• formulating scientific question • planning and carrying out investigations • comparing and interpreting results
The Frog Prince Focus: Density	Model experiments about density, reading data tables and calculating	• measuring weight • explaining phenomena by using models
The Emperor's New Clothes Focus: Thermal conductivity	Investigating the insulation properties of different textiles	• planning and conducting experiments that control variables • making measurements and producing data as the basis for evidence • error analysis and discussion of the results
Cinderella Focus: Separation of substances	Separation methods: filtration, skimming, evaporating, magnet separation, sieving	• planning and conducting experiments • error analysis and discussion of the results

Table 1. Overview over the four modules "Once upon a time"

Cinderella **–** *Focus: Separation of substances*
Students are introduced to separation methods by separating a mixture of ashes and lentils like Cinderella was instructed to do by her evil stepmother. In this module the students learn to relate the choice of separation method to the property of substances.

What to experience in our "fairy tale" workshop

All the experiments and materials used in the modules can be consulted and tried out during the workshop. The following table gives an overview over the experiments, the key aspects of student activity and the main areas of scientific methods.

Besides the presentation of the developed modules and trying out the experiments a central aspect of the workshop is to discuss to what extent the modules are actually adaptable for science lesson in different countries. This aspect and the feedback of the participants are of high interest for the teachers who developed the modules.

References

Bolte, C., Holbrook, J., & Rauch, F. (Eds.). (2012). *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project*. Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Bolte, C., Streller, S., & Hofstein, A. (2013). How to motivate students and raise their interest in chemistry education. In I. Eilks & A. Hofstein (Eds.), *Teaching chemistry – a studybook* (pp. 67–95). Rotterdam: Sense Publishers.

Finnish National Board of Education (2004). National core curriculum for basic education 2004. Retrieved from: http://www.oph.fi/english/curricula_and_qualifications/basic_education;47672_core_curricula_basic_education_3.pdf (19.05.2014).

Gesellschaft für Didaktik des Sachunterrichts (GDSU, 2003). *Perspectives framework for general studies in primary education*. Bad Heilbrunn: Klinkhardt.

NGSS Lead States (2013). Next Generation Science Standards: For states, by states. Washington DC: National Academies Press. Retrieved from: http://www.oph.fi/english/curricula_and_qualifications/basic_education (19.05.2014).

Streller, S. (2009). *Förderung von Interesse an Naturwissenschaften. Eine empirische Untersuchung zur Entwicklung naturwissenschaftlicher Interessen von Grundschulkindern im Rahmen eines außerschulischen Lernangebots*. Frankfurt a.M.: Peter Lang Verlag.

Streller, S., & Bolte, C. (2012). A longitudinal study on interests in science. *Proceedings of the European Science Educational Research Association (ESERA)*. Retrieved from: http://www.esera.org/media/ebook/strand10/ebook-esera2011_STRELLER-10.pdf (19.05.2014).

Streller, S., & Bolte, C. (2012). Science teachers cooperate: PROFILES teachers continuous professional development and the FU Berlin "ProNawi"-project. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 68–70). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

3.5 Learning With and About Advertising in Science Education

Nadja Belova & Ingo Eilks – Universität Bremen, Germany

Abstract

Advertising often contains factual information to make a campaign more credible and underline the effectiveness of a certain product. For many products this information is derived from science and technology. Understanding of the science in and behind those advertisings is necessary to react to them critically. Learning about the role of science in advertising also allows promoting societal-oriented communication and decision-making skills. However, up until now the issue of advertising in the science classroom has not been addressed systematically. This paper suggests a justification, strategies and pedagogies for the use of advertising in science teaching that were developed within the PROFILES project in Bremen.

Introduction

Advertising has huge impact on childrens' and young adults' lifestyle and behavior, for example, children's food consumption (Villani, 2001; Halford, Gillespie, Brown, Pontin, Dovey, 2003). For reacting self-determined to this influence students need to develop skills of how to respond critically to advertising and education needs to address corresponding aims (Brucks, Armstrong & Goldberg, 1988). Skills need to be developed to evaluate messages and facts behind advertisements as well as to understand the mechanisms of how advertisements are created and used to influence consumers (UNESCO, 2011). Advertising covers a broad range of products. Among them there are many products with a strong reference link to science and technology (Strange, 2008). This is why science education should concern with the learning about advertising. Such learning aims on contributing the development of critical media literacy in general, and concerning advertising literacy in particular.

The above made claim meets the ongoing debate to which degree science education should be re-focused towards a greater societal orientation for better preparing students for life in society (Hofstein, Eilks & Bybee, 2011) and to raise their perception of relevance of science education (Stuckey, Hofstein, Mamlok-Naaman & Eilks, 2013). But, although the debate is going on for several decades now, learning about the involvement of science with society still seems to be not sufficiently implemented in many countries (Hofstein et al., 2011). There are also only very few suggestions, materials and pedagogies available so far on the use of advertising in the science classroom (Belova & Eilks, 2014).

Within the framework of more societal-oriented science education one sub-set of innovations focuses the use of socio-scientific issues (SSI) in the science classroom (Sadler, 2011). Advertising about science and technology related products is a socio-scientific issue itself and might therefor be considered as a topic for SSI-based science education (Belova & Eilks, 2014). This is the reason that a part of the PROFILES project in Bremen intended to develop corresponding teaching and learning modules. Within an action research driven approach to curriculum development as part of PROFILES continuous professional development of teachers new pedagogies as well as teaching and learning materials were developed aiming at implementing learning with and about advertising in science teaching.

Advertising as 'filtered information'

In SSI-based science education some of the central objectives concern the promotion of societal-oriented communication and decision-making skills (Sadler, 2011). Communication – in particular argumentative communication – is the essential mediator of discourse and debate in society and the pre-requisite for decision-making (Nielsen, 2013). In society, debate takes place in public discussions, parliaments, the internet, mass media, or personal communication. Debate is influenced by newspapers, digital media, publications by interest groups and political stakeholders – and of course advertising. The individual as a responsible citizen has to deal informed with this kind of information to make up her or his mind and to become able to participate in personal and societal decisions. This concerns both the presented information itself as well as the way the information is presented to him (Hofstein et al., 2011).

Speaking about scientific information one has to be aware that the information presented to us through different channels is no longer authentically scientific, whether the source is TV, radio, newspapers, brochures or advertising. Every citizen is confronted with this kind of altered information, or better named 'filtered information' (Hofstein et al., 2011). Everyone has to deal with it to make up her or his mind. In other words, for every non-scientist the way available information for understanding a socio-scientific issue takes is long and indirect. In a lot of single steps the original information is processed and filtered from science via the media towards the individual. This processing and filtering is done by individuals or groups through selecting, simplifying, and interpreting the information in each of these steps. This process described e.g. in Eilks, Nielsen & Hofstein (2014) also applies to advertising (see Figure 1).

The further we move from science towards everyday life the more the information most probably is filtered and altered. The further we leave the domain of authentic science itself, the greater the chance is that the persons involved do not apply comprehensive subject matter knowledge necessary for securing reliability of the information transfer. As a result, the interaction with science-related information in everyday settings does not need only a simple evaluation of the pertinent scientific facts. Frequently, it is just as – if not more – important to understand which pathway the information followed and which interests have played a role in its transfer.

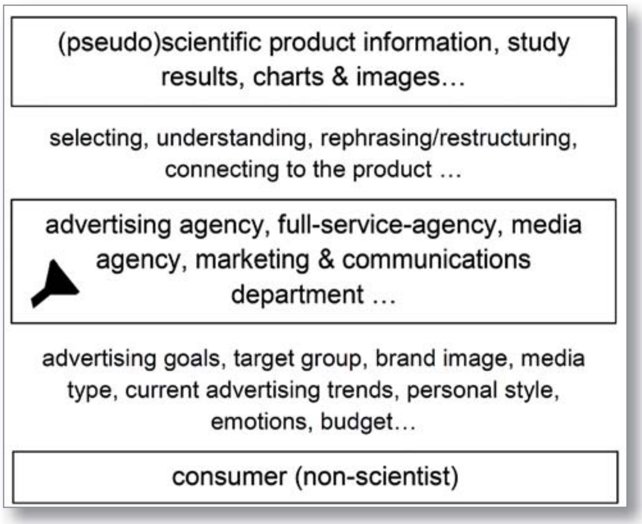


Figure 1. The doubled filtering process of scientific information transfer from Eilks et al. (2014) applied to advertising

Since this process of information filtering is also part of advertising, advertising can be used both as an example for the information filtering process ("learning with advertising") as well it can become the SSI itself ("learning about advertising"). Not only can we motivate or illustrate certain scientific topics by appropriate advertising, it can also be learned and reflected how scientific information is used in advertising, how it is presented, which effect it has on the credibility of the advert, whether wrong and misleading information is used, and what it does to the consumer.

Learning with and about advertising in the science classroom

Corresponding to the curriculum development process on learning with and about advertising in science education within the PROFILES project in Bremen, several roles of advertising in science education have been worked out. These roles concern (i) motivation for science learning, (ii) contextualization of science learning, (iii) critically reflecting the socio-scientific claims in advertising, and (iv) reflecting the use of scientific information within the process of making advertising (Belova & Eilks, 2014). Especially concerning strategy (iv) innovative pedagogies and corresponding classroom materials were developed. Topics taken in focus were: Energy Drinks, Sweeteners, Cosmetics, Protein Shakes, and Bioplastics.

In the "advertising method" on the above mentioned examples students receive pre-selected, authentic claims for a certain product. The claims encompass techno-scientific arguments, but also cover information bits from other sources with respect to the given product, like economic, ethical, practical or aesthetical arguments. Students are asked in a first step to sort the claims in supportive (positive or positively appearing) and non-supportive (negative) information. They analyze information to whether it can be used in advertisings for a certain product and then have to decide which to use. In the end they make their own advertising and reflect whether to use claims from science, or not.

Another pedagogy deals with reflecting advertising slogans. In this method the students receive a selection of authentic slogans for a certain product (Figure 2). The slogans are evaluated regarding credibility, attractiveness and their relationship to the scientific information behind them. Discussion is initiated which slogans base on scientific facts or address scientific thinking. Reflection is initiated whether the use of science correlates with the target group of the advertising and how it might influence the potential perception of the slogan by the consumers.

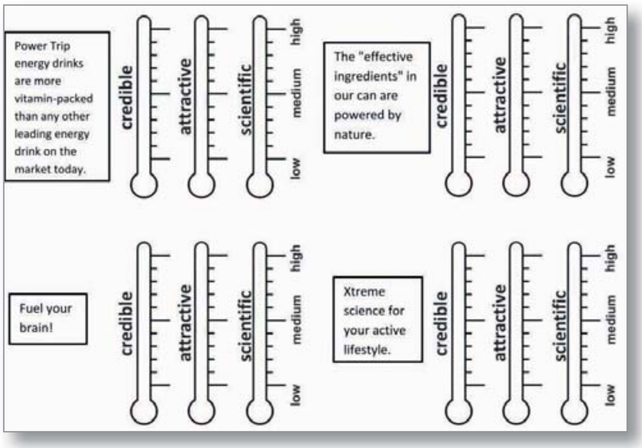


Figure 2. Advertising slogans for energy drinks (excerpt from a corresponding worksheet)

As for the structure of the workshop, in the very beginning, a theoretical legitimation on the use of advertising in the science classroom is given to the participants. The described strategies, methods and examples are presented and discussed. In the practical phase, some of the methods are tried out by the participants. After the practical phase, the versatility of such methods in the science classroom is discussed. It is also discussed whether advertising itself should play a role in science education. At the end of the workshop, some insights in the trials of the methods are given.

Conclusions

Learning about advertising is important for the development of critical consumership. Learning with advertising can be motivating and can contextualize science learning. However, connected to learning about the processes of information use in advertising has potential also for contributing to multidimensional scientific literacy and critical media literacy. In this case it has potential to contribe to socio-scientific communication and decision-making skills.

References

Belova, N., & Eilks, I. (2014). Promoting societal-oriented communication and decision-making skills by learning about advertising in science education. *Centre of Educational Policy Studies Journal, 4*, 31–49.

Brucks, M., Armstrong, G. M., & Goldberg, M. E. (1988). Children's use of cognitive defenses against television advertising: A cognitive response approach. *Journal of Consumer Research, 14*, 471–482.

Eilks, I., Nielsen, J. A., & Hofstein, A. (2014). Learning about the role of science in public debate as an essential component of scientific literacy. In A. Tiberghien, C. Bruguière, & P. Clément (Eds.), *Topics and trends in current science education* (pp. 85–100). Dordrecht: Springer.

Halford, J. C., Gillespie, J., Brown V., Pontin E. E., & Dovey, T. M. (2003). Effect of television advertisements for foods on food consumption in children. *Appetite, 42*(2), 221–225.

Hofstein, A., Eilks, I., & Bybee, R. (2011). Societal issues and their importance for contemporary science education: a pedagogical justification and the state of the art in Israel, Germany and the USA. *International Journal of Science and Mathematics Education, 9,* 1459–1483.

Nielsen, J. A. (2013). Dialectical features of students' argumentation: a critical review of argumentation studies in science education. *Research in Science Education, 43*, 371–393.

Sadler, T. D. (2011). *Socio-scientific issues in the classroom*. Heidelberg: Springer.

Strange, P. (2008). *Clinically unproven. On the misuse of science in advertising.* Retrieved from: www.lablit.com/article/426 (01.08.2013).

Stuckey, M., Hofstein, A., Mamlok-Naaman, R., & Eilks, I. (2013). The meaning of 'relevance' in science education and its implications for the science curriculum. *Studies in Science Education, 49*, 1–34.

UNESCO (2011). *Media and Information Literacy. Curriculum for Teachers*. Retrieved from: http://unesdoc.unesco.org/images/0019/001929/192971e.pdf (05.05.2014).

Villani, S. (2001). Impact of media on children and adolescents: A 10-year review of the research. *Journal of the American Academy of Child and Adolescent Psychiatry*, 392–401.

3.6 Meaningful Problem Solving: a Powerful Tool for Reasoning and Deep Learning

Liberato Cardellini – Università Politecnica delle Marche, Italy

Abstract

Problem-solving is an important topic for both cognitive psychology and education. Unfortunately, the same word 'problem' has a negative connotation; just think of the phrase "having a problem." A problem is a situation, matter, or person that presents perplexity or difficulty. In more scientific terms, "Whenever there is a gap between where you are now and where you want to be, and you don't know how to find a way to cross the gap, you have a problem" (Hayes, 1989, p. 7). Problem-solving is a process in which various reasoning patterns are combined, refined and extended. It is much more than substituting numbers in well-known and practised formulas: it deals with creativity, lateral thinking and formal knowledge. For this reason, and its importance in the acquisition of reasoning, problem-solving is very much related with the PROFILES project. Through solving logical problems, participants discover general problem-solving strategies (the so called weak methods). Examples of creative solutions devised by students in solving chemical problems, in university courses where a great emphasis is placed on the students' motivation are shown.

Introduction

Problem solving is an essential activity in education and teaching. According to Watts (1991, p. 15) there are eight reasons that justify the solution of problems:

- problem-solving enables youngsters to take ownership of a task
- it encourages decision-making and many social skills
- it is a form of both active learning and discovery learning
- it is a vehicle for teaching many scientific skills, and for reaching the content aspects of science
- it allows cross-curricular activity
- it provides relevance and real-life contexts
- problem-solving and creative thinking are among the highest and most complex forms of human activity
- it enhances communication.

Problem solving skills, argumentation and communication are considered important by the above descriptors and the promotion of skills in problem-solving and critical thinking is the hallmark of science teaching.

In ordinary language, the word problem has a negative connotation: just think of the phrase "having a problem." The term 'problem' is defined in the Oxford Dictionary as

> *"A matter or situation regarded as unwelcome or harmful and needing to be dealt with and overcome; a thing that is difficult to achieve; an inquiry starting from given conditions to investigate or demonstrate a fact, result, or law."*

In more scientific terms,

> *"Whenever there is a gap between where you are now and where you want to be, and you don't know how to find a way to cross the gap, you have a problem"* (Hayes, 1989, p. 7).

A further definition comes from Karl Dunker:

> *"A problem arises when a living creature has a goal, but does not know how this goal is to be reached"* (Dunker, 1945, p. 1).

The idea of 'problem' is associated with cognitive difficulties and the need to resort to knowledge. From these definitions, it follows that not all 'problems' are real problems: without the cognitive difficulties the 'problems' to be solved are exercises. In general, it is not possible for teachers to determine whether a problem is a real problem, or an exercise. This is because

> *"its status as a problem is a subtle interaction between the task and the individual struggling to find an appropriate answer or solution"* (Bodner, 1987, p. 513).

Problem solving is an important activity in teaching, because

> *"problem-solving requires argumentation. Argumentation is a process of making claims and providing justification for the claims using evidence. Argumentation is an essential kind of informal reasoning that is central to the intellectual ability involved in solving problems, making judgments and decisions, and formulating ideas and beliefs. Argumentation requires problem solvers to identify various alternative perspectives, views, and opinions; develop and select a preferred, reasonable solution; and support the solution with data and evidence"* (Cho & Jonassen, 2002, p. 5).

A study on problem-solving

For many years, I study the ability of students with respect to the transformations of atoms and molecules, into mass (in grams) and vice versa. On the first day of class I ask my students to complete the Friedel-Maloney's questionnaire (Friedel & Maloney, 1995). This measures the ability to use the relationship between atomic mass, the molar mass, the mass of the substance and Avogadro's number, based on calculations involving atoms and molecules, by means of four problems. The use of appropriate representations helps to improve the skill in determining the solution to this kind of problem (Chi, Feltovich & Glaser, 1981). Recently, repeating the test in the last lesson of the course, the results from the first day show a very modest improvement. So it was decided to modify the approach and use the worked examples method, as suggested by Sweller (2006).

Five problems, two worked problems, and three suggested problems to be solved were used in this experiment. The worked examples provided students with all the information regarding the solution of the problem. The study included 123 freshmen students, enrolled in the first year of a chemistry course in the second semester of the academic year 2013–14. Of these, 112 were male (91%) and 11 female (9%). The age of the students was 19–21. The actual course was held in the first semester of the academic year 2013–2014, for a workload of 9 ECTS credits. The results referred to tests administered on the first day of the course and repeated after two weeks. In addition, to worked examples, students have practiced with other problems, reported in the textbook.

Examples in the test, with the subsequent outcomes, were:

1. How many oxygen atoms are present in a container with 288 g of O_3? (molar mass of O_3 is 48.0 g)
   a) $3.61x10^{24}$

b) 18.0
c) $1.08x10^{25}$
d) $1.20x10^{24}$

Outcome:

N	a	b	**c***	d
91	37	2	50 (54.9)	2
39	4	0	35 (89.7)	0

2. There are $1.8x10^5$ atoms in a sample of P_4. What is the mass of this sample? (Molar mass of P_4 is 124 g.)
   a) $9.3x10^{-18}$
   b) $3.7x10^{-17}$
   c) $5.6x10^6$
   d) $1.5x10^{-16}$

Outcome:

N	**a***	b	c	d
90	37 (41.1)	45	6	2
39	28 (71.8)	11	0	0

3. How many atoms of sulphur are in a sample of 963 g of S_6? (gram atomic weight of S is 32.1 g).
   a) $3.01x10^{24}$
   b) 30.0
   c) $5.02x10^{23}$
   d) $1.81x10^{25}$

Outcome:

N	a	b	c	**d***
85	31	5	0	49 (57.6)
39	5	0	0	34 (87.2)

4. There are $2.41x10^{24}$ atoms in a sample of S_8. What is the mass of this sample? (gram atomic weight of S is 32.1 g)
   a) 16.1 g
   b) $7.74x10^{25}$ g
   c) 128.4 g
   d) $9.68x10^{24}$ g
   e) $1.03x10^3$ g

Outcome:

N	a	b	**c***	d	e
86	11	2	48 (55.8)	0	25
39	1	0	26 (66.7)	0	12

Problem-solving according to the PROFILES philosophy

The improvements were substantial; probably not only for the use of worked examples, but also for the use of a cooperative learning method. According to Bolte, Streller & Hofstein (2013, p. 83)

> *"Learning environments, which are potentially motivating to the students, are ones where students can share learning experiences and perspectives with each other, through social interaction and cooperative work."*

Even at the university, motivation plays an important role. The initial problems faced by the students were logic problems (Cardellini, 2006). Many students love the fun that comes from the challenge that the problem arises with the ability of those who solve the problem. Despite all efforts to motivate them, about half of the students abandoned the course. This fact highlights the urgency of using the PROFILES philosophy at all levels of education.

Students are encouraged to solve problems, explaining and arguing the steps in their solution. From previous learning at schools, the students are used to solving problems by applying one or more formulas. Solve problems in a meaningful

Figure 1. Despite the workload required in the course, many students were quite happy to work in this engaged way

way involving reasoning required a lot of effort on the part of the students and many students have practiced fairly systematically in solving problems. From each lesson, I gathered the problems solved: more than 7,000, with the average value is 145.3 (DS = 87.8: from 22 to 373, N = 49).

In a questionnaire completed by students in a previous course after passing the exam, the question: there was too many problems to be solved scored 3.03, while the question: I like to solve stoichiometric problems scored 5.50 out of 6 (N = 30 students). The downside to this approach is that it requires much effort and some students are not willing to work systematically and so they leave the course.

In the workshop, after a presentation of the Human Cognitive Architecture (Sweller, Ayres & Kalyuga, 2011), you can work to solve logical problems, with the intent to highlight the problem analysis and the search for effective strategies for obtaining the solution. The solution of problems (of any kind), in an approach of education through science (Holbrook, 2010) can make a difference in the cognitive abilities of the students and their motivation towards the study. Teaching in order to engage students with meaningful activities is crucial, because, as stated by Jonassen (2013),

> *"I argue that problem-solving, analogizing, modelling, reasoning causally, and arguing are the most powerful modes of thinking that lead to the most meaningful learning. These are the most cognitively engaging and epistemic productive learning activities that students may complete."*

References

Bodner, G. M. (1987). The Role of Algorithms in Teaching Problem Solving. *Journal of Chemical Education, 64*(6), 513–514.

Bolte, C., Streller, S., & Hofstein, A. (2013). How to motivate students and raise their interest in chemistry education. In I. Eilks & A. Hofstein (Eds.), *Teaching chemistry – a studybook*. Rotterdam: Sense Publishers.

Cardellini, L. (2006). Fostering creative problem-solving in chemistry through group work. *Chemistry Education Research and Practice, 7*(2), 131–140.

Chi, M. T. H., Feltovich, P. J., & Glaser, R. (1981). Categorization and Representation of Physics Problems by Experts and Novices. *Cognitive Science, 5*, 121–152.

Cho, K.-L., & Jonassen, D. H. (2002). The effects of argumentation scaffolds on argumentation and problem-solving. *Educational Technology Research and Development, 50*(3), 5–22.

Dunker, K. (1945). On problem-solving. *Psychological Monographs, 58* (Whole No. 270), i–113.

Friedel, A. W., & Maloney, D. P. (1995). Those Baffling Subscripts. *Journal of Chemical Education, 72*(10), 899–905.

Hayes, J. R. (1989). *The complete problem solver*, 2nd Ed., Hillsdale, NJ: Erlbaum.

Holbrook, J. (2010). Education through science as a motivational innovation for science education for all. *Science Education International, 21*(2), 80–91.

Jonassen, D. H. (2013). First principles of learning. In J. Michael Spector, B. B. Lockee, S. E. Smaldino, & M. C. Herring (Eds.), *Learning, Problem Solving, and Mindtools. Essays in Honor of David H. Jonassen* (pp. 287–288). New York: Routledge.

Sweller, J. (2006). The worked example effect and human cognition. *Learning and Instruction, 16*(2), 165–169.

Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive Load Theory*. Boston, MA: Springer.

Watts, M. (1991). *The Science of Problem-solving. A Practical Guide for Science Teachers*. London and Portsmouth, NH: Cassell.

3.7 How Teachers Can Learn to Reflect and Collaborate: Experiences from Latvia

Dace Namsone & Līga Čakāne – University of Latvia, Latvia

Abstract

Two teachers' professional learning models were implemented in Latvia within the FP7 Science in Society, project PROFILES with an emphasis on teachers' collaboration. The first model covers the joint observation of lessons in a real-life classroom environment, and lesson analyses on the development of the capability of simultaneously teaching scientific inquiry skills, collaboration skills and reflection skills. The second model covers a teachers' learning team for action research. The goal of the second model is the individual improvement of inquiry teaching skills, reflection and collaboration skills. The survey of teachers, conclusions of experts and teachers' feedback, all demonstrate that the models enhances the development of science teachers' reflection and collaboration skills.

Introduction and rationale

The teachers' professional learning models were implemented in Latvia within the FP7 Science in Society project, PROFILES of, with an emphasis on teachers' collaboration within school networks.

There was a strong need to develop new forms of teachers' continuous professional development in Latvia. If a teacher lacks the skills to use inquiry modules (no difference whether a local or PROFILES module), students fail to experience meaningful and efficient learning in the classroom. Neither students nor the teachers, themselves, see any benefits from such insufficient methods of studies, because they lack student involvement. A teacher is the key for scientific inquiry to succeed; therefore he/she needs the necessary teaching skills, experience in teaching of scientific inquiry elements and an awareness of the benefits that this kind of teaching brings to the students and him/herself as a professional. Accordingly, one of the ways teachers can improve their teaching experience and skills is to create a system, which enables teachers to learn from each other and share their best practices of teaching using scientific inquiry. This means that, along with the traditionally hierarchical teachers' in-service training patterns, different forms have to be sought, such as collaboration and teacher's mutual experience exchange-based models. In the case of Latvia, this means both changing a teacher's practices in the classroom and, at the same time, the training process.

A discrepancy exists between the teachers' self-defined learning needs and observations by experts. According to the experts' conclusions, teachers possess insufficient inquiry teaching, as well as reflection and collaboration skills.

According to the literature it is assumed that improvement in teaching is a collective, rather than individual, enterprise and that analysis, evaluation and experimentation, in concert with colleagues, are the conditions under which teachers improve (Rosentholtz, 1991). The learning message is rather about teachers being open to evidence of their impact on students, critiquing each other's impact in the light of evidence on such impacts, and forming professional judgements about how teachers then need to – and indeed can – influence learning of all students in their class (Hattie, 2012). Well-developed teamwork improves the quality of practices, as teachers work and learn from each other (Fullan, 2011). Despite the evidence and the fact that almost every other profession conducts most of its training in real-life settings, very little teacher training takes place in a teacher's own classroom, the precise place in which it would be relevant enough to be most effective (Barber & Mourshed, 2007). To improve teachers' individual teaching and reflection skills, an action research model was chosen. Action research is seen as a deliberate, solution-oriented investigation that is group or personally owned and conducted (Kemmis & McTaggart, 1988).

The possibilities of exploiting models for teachers' professional learning were considered to develop reflection and collaboration skills on the basis of scientific inquiry teaching and learning within the real classroom practice. Two models with the same philosophy were developed. The first model focused on practical school-based workshops for teachers, with observing and then analysing the lessons observed together (real classroom environment). Cooperation within this model was seen as sharing (materials & teaching strategies) and joint collaborative work – where teachers planned, or together included, into teaching. The second model focused on how to start action research in their teaching practice as a tool to improve individual teaching and reflection skills. The conjunctive elements for both models were the following: teachers together could learn from each other to reflect about teaching practice by going through a multiple activity cycle „observe or do – reflect – write – discuss," a few times during every workshop and many times during the whole cycle of workshops in the network. The models were based on real-life school practice, where teachers could learn how to reflect and at the same time, learn particular methods, ideas, etc. from each other, where teachers learned by collaboration and experience exchange, and where teachers felt support from their colleagues.

Method

The research question – Are the newly implemented models useful for improving teachers' scientific inquiry teaching, collaboration and reflection skills? – was tested. The source for data collection was a PROFILES teacher needs questionnaire (92 respondents, 2011), which served as a tool to study teachers' self-reporting learning needs. The impact of the training workshops was analyzed with the help of teacher questionnaires (in 2012, 74 respondents and in 2013, 85 respondents), and analyses of the written feedback after seminars. Experts gave conclusions drawn from focus groups discussions after each workshop. The action research group results were analyzed according to pre- and post-tests, the data recorded during workshop sessions.

The piloting and practicing of these new models formed the network of innovative experience, developed with the help of municipalities and the National Center for Education. The first model was implemented in network schools. Every network school created a team of science and maths teachers and teams of teachers from the national network were divided into regional groups. For example, the Riga group included 23 chemistry, physics, biology and math teachers from six schools in the Riga area, plus six school leaders. Learning was carried out during the two school years, from November 2011 until April 2013. Each group participated in two cycles of five workshops, each of which took place in a different school and included real-life observation of lessons with joint lesson analysis, as well as input sessions on a particular issue. The length of one workshop was six to eight sessions (40 minutes each).

The learning teams for action research were implemented within the network and a new group was developed for PROFILES teachers without experience in teaching scientific inquiry.

Results and discussion

Results from the first model of teachers' professional learning indicated that it facilitated the development of teachers' scientific inquiry teaching skills, reflection and collaboration skills. This finding is supported by the responses of teachers, experts in focus groups and teachers' feedback. For example, teachers indicated in a questionnaire they had improved skills to reflect on their performance with colleagues (58% fully agree, 39% agree). During the cycle of workshop experiences, the time and depth of teachers' reflection increased and teachers' awareness of the importance of lesson analyses deepened.

From implementing the second model, the team for action research was questioned by different groups of teachers. Teachers mentioned progress in teaching practice and reflection skills (pre- and post-tests, Likert scale 0–3). The team leaders pointed out the teachers' professional progress.

It is important to note that the participants were experienced and enthusiastic teachers, eager to make changes happen and that the teachers and experts enjoyed a mutual trust, which certainly contributed to the excellent outcome. The proficiency of experts and learning team leaders grew together with the participants' experiences, jointly working on the development of a new model of teacher professional learning.

References

Barber, M., & Mourshed, M. (2007). *How the world's best performing school systems come out on top*. McKinsey & Co.

Fullan, M.G. (2011). *Innovative teaching and learning research. 2011 Findings and Implications*. Retrieved from: http://www.itlresearch.com/images/stories/reports/ITL%20Research%202011%20Findings%20and%20Implications%20-%20Final.pdf (01.07.2014).

Hattie, J. (2012). *Visible learning for teachers. Maximizing impact of learning*. London and New York: Routledge.

Kemmis, S., & McTaggart, R. (2000). Participatory action research. In N. Denzin & Y. Lincoln (Eds.), *Handbook of Qualitative Research*. London: SAGE.

PROFILES. (2010). *The PROFILES Project.* Retrieved from: http://www.profiles-project.eu/work_packages/index.html (01.07.2014).

Rosentholtz, S. I. (1991), *Teachers workplace: The social organization of schools*. Harlow, UK: Longman group.

3.8 Technological Support for Inquiry-based Learning: Development of Digital Resources in Science Education Using Web 2.0 Tools

João Paiva, Carla Morais & José Barros – Faculdade de Ciências da Universidade do Porto
Nuno Francisco – Faculdade de Ciências da Universidade do Porto & Colégio Cedros, Colégios Fomento
Luciano Moreira – Faculdade de Engenharia da Universidade do Porto, Portugal

Abstract

The reported decline in European students' interest in learning science is disconcerting. It is necessary to implement teaching strategies that enable students to understand the usefulness of learning science and the relevance of scientific knowledge. The social WEB is a strong collaborative environment, in which users are encouraged to participate in the construction of knowledge, as the new tool enable them to add, modify and comment on content. Given the importance of the pedagogical integration of technology, in this workshop we present examples of web 2.0 tools that allow the development of digital learning resources by teachers, their adaptation for students and the curriculum, in order to enhance the learning of science, making it more effective and meaningful for students. It is necessary that each teacher contributes actively to promote students' motivation for learning science, always incrementing a solid scientific literacy. It is this line of thought that justifies our commitment with the development of more and better digital resources, potentially useful for the teaching of science at different levels of schooling. Thus, we challenge participants to engage in the process of developing digital educational resources.

Introduction

The reported decline in European students' interest in learning science that has been reported is disconcerting. It's necessary, therefore, to implement teaching strategies that enable students to understand the usefulness of learning science and the relevance of scientific knowledge.

The potential of digital technologies offers new opportunities to support inquiry-based learning. For example, the use of computer simulations is a successful way to promote the abstraction that is required to achieve a sustained understanding of scientific concepts, because they facilitate "learn by doing" (hands-on, minds-on), which increases the curiosity and interest of the students. Computing and networking technologies offer numerous new opportunities to support inquiry-based learning. For instance, in their analysis of technology as a support for project-based science learning, Blumenfeld et al. (1991) identified six contributions that technology can make to the learning process:

- Enhancing interest and motivation
- Providing access to information
- Allowing active, manipulable representations
- Structuring the process with tactical and strategic support
- Diagnosing and correcting errors
- Managing complexity and aiding production

All of the fundamental properties of computing technologies offer benefits for inquiry-based learning: the ability to store and manipulate large quantities of information; the ability to present and permit interaction with information in a variety of visual and audio formats, the ability to perform complex computations, the support for communication and expression, and the ability to respond rapidly and individually to users. In the inquiry-based learning approach, computer technologies can be used to provide investigation tools, knowledge resources, and record-keeping tools (Edelson, Gordin & Pea, 1999).

Principles and tools of Web 2.0

Web 2.0 refers to a setting of new techniques to design and implement web-pages available on the World Wide Web (O'Reilly, 2007). This new Web generation, also known as social Web, is a strong collaborative environment. Users are encouraged to participate in the construction of knowledge as the new tools enable them to add, modify and comment on content.

This way of developing web content has facilitated the creation of spaces with strong social characteristics, or "affinity spaces" (Jenkins, 2006). We are now facing a web in which tools and applications are progressively more user-friendly, enabling more and more people to use them to build and share knowledge.

Eijkman (2008) suggests that the Web 2.0 has the potential to provide users with new types of learning environments and represents a new paradigm, because its participatory architecture privileges a more inclusive and global way of building knowledge through the activation of networking. It is in this context and within this architecture that the Web 2.0 offers users numerous tools that can be used for educational ends, namely, for developing digital educational resources.

Digital educational resources	Examples of Web 2.0 tools
Digital educational games	"Sploder"; "Kodu"; "ABCya"
Animations	"FluxTime"; "GoAnimate"; "Powtoon"
Videos	"Animoto"; "Kids´Vid"
E-books	"Storyjumper", "TikaTok"
Cartoons	"Toondoo"

Table 1. Typology of digital educational resources and web 2.0 tools

Short comments on the workshop

The second generation Web, together with its user-friendly, free and open-source tools, can be an important ally in the process of building and disseminating science, in general, and chemistry, in particular.

Given the unquestionable importance of pedagogical integration of technology, in this workshop we present examples of tools from Web 2.0 that can allow the development of digital learning resources by teachers. Teachers can adapt them for their students and their curriculum, in order to enhance the learning of science, making it more effective and meaningful for students. Thus, in this workshop, we challenge the participants to engage in the process of developing digital educational resources. The participants have the opportunity to produce digital educational resources that fit in typology presented in Table 1 by managing some of the tools listed.

In addition to developing little digital educational resources, the participants are invited to reflect on the content and communicational strategies, based on Web 2.0 tools, valuing scientific knowledge and its integration and organization in digital media.

Outlook

It is necessary that each teacher contributes actively to promote students' motivation for learning science, always incrementing a solid scientific literacy. It is this line of thought that justifies our commitment to the development of more and better digital resources, potentially useful for the teaching of science at different levels of schooling.

References

Blumenfeld, P. C., Soloway, E., Man, R., Krajcik, J. S., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist, 26*, 369–398.

Edelson, D. C., Gordin, D. N., & Pea, R. D. (1999). Addressing the challenges of inquiry-based learning through technology and curriculum design. *Journal of the Learning Sciences, 8*(3&4), 391–450.

O'Reilly, T. (2007). What is Web 2.0: Design patterns and business models for the next generation of software. *Communications & Strategies, 65*.

Jenkins, H. (2006). Confronting the Challenges of Participatory Culture: Media Education for the 21st Century. Retrieved from: http://mitpress.mit.edu/sites/default/files/titles/free_download/9780262513623_Confronting_the_Challenges.pdf (29.05.2014).

Eijkman, H. (2008). Web 2.0 as a non-foundational network-centric learning space. *Campus-Wide Information Systems, 25*(2).

4 POSTER CONTRIBUTIONS REGARDING EVIDENCE-BASED EXPERIENCES WITHIN PROFILES

4.1 The PROFILES Network in Austria

Franz Rauch, Mira Dulle & Kristina Zoe Römer – Alpen-Adria-Universität Klagenfurt, Austria
Ilse Wenzl – Austrian Educational Competence Centre Biology, Universität Wien, Austria

Abstract

Based on the Regional Network Programme of the Austrian national project IMST – Innovations make Schools Top, the Austrian PROFILES Network was established in Vienna in 2011. Approximately 45 interested teachers cooperate in the network that is formed as a Community of Practice (CoP). Within the PROFILES Continuous Professional Development (CPD) courses as well as additional informal meetings, the community members develop PROFILES modules and reflect on their implementation in class. Out of this group, 11 teachers took in the function of so called lead teachers (Hofstein, Mamlok-Naaman, Katchevitch, Rauch & Namsone, 2012), spearheading the professional development of additional teachers at pre- and in-service levels, initiating workshops for key stakeholders and extending the PROFILES network. Evaluation data show that the participating teachers developed a high level of ownership regarding the PROFILES project and the CPD courses as well as a sense of self-efficacy regarding the project and instructional strategies. Pupils are motivated during the implementation of the modules and a positive learning effect can be observed. They enjoy learning with a high degree of autonomy and the teachers see this as a relief compared to their regular lessons. Pupils indicate they develop more self-confidence regarding their knowledge and competences. The Austrian PROFILES Network develops dynamically and it is expected to continue after the end of the PROFILES project. The paper includes evaluation data from the project IMST that focuses on self-evaluative measures, consisting of qualitative and quantitative surveys (Wenzl, 2012). Furthermore, interview and feedback data (reflective papers) from PROFILES teachers, as well as an action research case study are included.

Within PROFILES, every partner country is setting up a teacher network (in cooperation with other networks) to both maximise the dissemination and to make teachers more aware of the PROFILES project and its goals (Rauch & Dulle, 2012; Rauch, Dulle, Namsone & Gorghiu, 2014). Networks at the level of teacher-groups, schools and local structures are likely to be closely linked to instruction and may contribute the most to improvements in the regional structures (Altricher, Rauch & Riess, 2010).

Austria has a well-implemented structure of educational networks. The nation-wide 'IMST' (Innovations Make School Top) project aims at improving instruction in mathematics, science, IT, German language and related subjects. To put innovative instructional projects into practice, IMST supports regional networks in all nine Austrian provinces, and three thematic networks which operate at national level. To some extent, they fill the gap of lacking subject didactic centres in higher education throughout Austria and provide research-based didactic professional development for teachers (Rauch, 2013).

The Regional Science Network Vienna was developed within the frame of the project IMST in 2004. A focal point is the improvement of quality as a new culture in education, including the concepts of sustainability, reflection, individualisation and the development of communities. Furthermore, the Regional Science Network Vienna aims at establishing co-operations with other educational institutions, like AECCs (Austrian Educational Competence Centres) and other Austrian networks (Wenzl, 2012). The Regional Science Network Vienna provides support for conducting evaluation studies and the implementation of innovative teaching methods (e.g. inquiry learning), disseminated by different means, especially by presentations of good practice and materials which were proven in class. This helps the dissemination of current developments. The Regional Science Network Vienna is used as a hub for information from superordinate institutions that do not have direct contact to the "basis". Due to the manageability of the network structure, the Regional Science Network Vienna is able to act quickly when it comes to information sharing. This is an advantage compared to other administrative institutions in the field (like school authorities, Universities and Colleges) and strengthens its position as a contact point for different organisations. The Austrian ministry of education and the Vienna School Council support the network regarding the organisation of events, dissemination and by providing value units for teachers. Through diverse activities and co-operation, the Regional Science Network Vienna is able to reach teachers and pupils as well as scientists.

The focus on inquiry learning as well as its good connections and expertise made the Regional Science Network Vienna a successful basis for the development of an Austrian PROFILES Network. The coordinator of the Regional Science Network Vienna provided continuous professional development (CPD) courses, sharing the PROFILES philosophy and inquiry-based teaching modules. From 2011 to 2013, approx. 50 teachers from Vienna and Lower Austria attended these courses. To structure the participation of teachers, a *community of practice* was developed (Wenger, 1998), including approx. 40 teachers. A Community of Practice (CoP) is defined as

> *"a group of professionals informally bound to one another through exposure to a common class of problems, common pursuit of solutions, and thereby themselves embodying a store of knowledge"* (Hildreth & Kimble, 2000, p. 3), and as

> *"groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis"* (Wenger, McDermott & Snyder, 2002, p. 7).

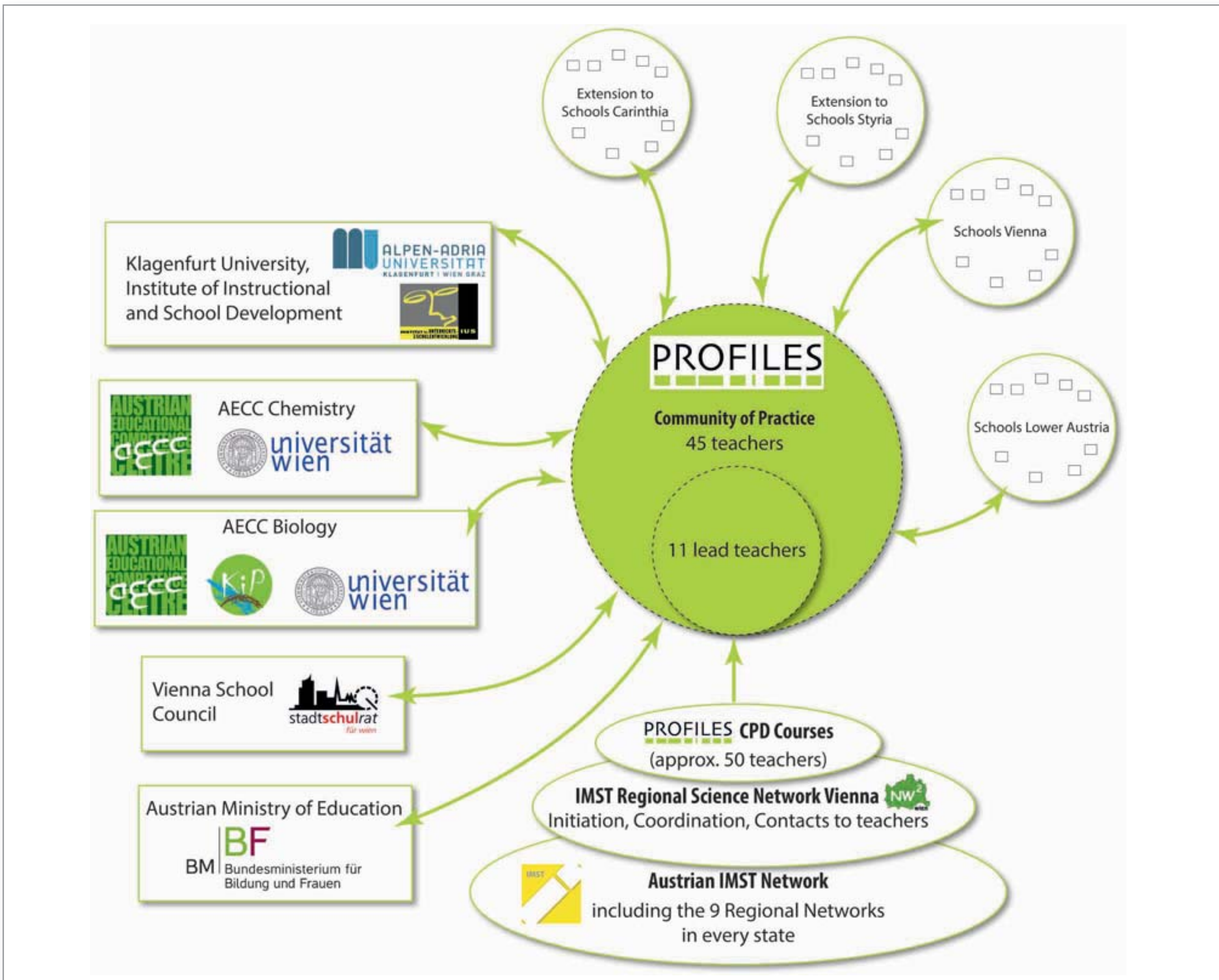


Figure 1. Austrian PROFILES Network

In the initial phase of establishing the CoP, challenges could be seen in the coordination and motivation of teachers. The participation was voluntary and based on personal interest, including the possibility for members to enter and leave the community at any time. Although some members who joined the CoP in the beginning left after some time, new members enter it constantly. Therefore, the CoP reaches more and more participants and fulfils its aim of dissemination. To get teachers actively involved at the beginning, the CoP needed coordination. For that reason, the coordinator of the Regional Science Network Vienna oversaw the coordination of the CoP, which was supportive regarding the exchange of know-how between the PROFILES-CoP and the Regional Science Network Vienna (see Figure 1). In that way, the CoP could be regarded as a loosely coupled sub-structure of the Regional Science Network Vienna. As a regular working group, the CoP was characterized by cooperation and reflection. The members met several times per semester, in addition to the CPD courses. Teachers developed inquiry-based teaching modules in groups, implemented them in the classroom, and jointly reflected on their experiences.

> *"You do not merely develop a module; you discuss it, read literature, do research, adapt and exchange materials, and finally you implement it in class and evaluate it"* (teacher comment).

Out of this group, 11 teachers were very active and worked intensively and independently. These teachers overtook the function of so called lead teachers (Hofstein, Mamlok-Naaman, Katchevitch, Rauch & Namsone, 2012), spearheading the professional development of further teachers at pre- and in-service levels, initiating workshops for key stakeholders and extending PROFILES networking.

> *"Our teachers multiplied what they developed because they brought it to their own schools"* (coordinator of the Regional Science Network Vienna).

The idea was that those teachers who developed a high level of ownership would, in the future, after the formal end of the PROFILES project, become leading teachers who would continue to develop and implement PROFILES ideas and pedagogy.

To identify the level of ownership of those teachers participating in the PROFILES CoP we used two questionnaires, forwarded by the Weizmann Institute: the Ownership Questionnaire and the Self-efficacy Questionnaire (Katchevich, Hofstein, Yayon & Mamlok-Naaman, 2014).

Eight teachers filled out the Ownership Questionnaire. The results showed that clearly all investigated teachers developed a high level of ownership regarding all six categories because, on a scale from 1 ("I strongly agree") to 6 ("I don't agree"), no mean value exceeds the value of 3,50 (see Table 1).

Picture 1. The development and reflection on PROFILES modules within the Austrian PROFILES Network

Teachers	Feeling and acting for sharing and disseminating PROFILES modules	Willingness to continue and participate in the CPD programme	Feeling empathy towards the project and believe in its rationale	Promotion of teacher's status among peers	Promotion of teacher's status in his/hers classroom	Feelings referring to professional development of teachers
T1	2,25	2,75	1,83	3,00	2,25	3,20
T2	2,25	1,00	1,83	2,00	2,00	2,00
T3	2,00	1,25	1,83	3,00	1,75	1,60
T4	1,00	1,00	1,83	2,50	2,25	1,60
T5	2,00	1,50	1,83	2,83	3,50	1,20
T6	1,25	1,25	2,00	1,83	1,75	2,00
T7	2,25	2,25	2,17	2,40	n.a.	2,20
T8	2,33	2,50	2,50	3,33	3,25	3,20
Total sample	1,9167	1,6875	1,9792	2,6125	2,3929	2,1250

(1 = "I strongly agree"; 6 = "I don't agree")

Table 1. Ownership means per person and category and for the total sample

Five teachers indicated, through a mean value of 1,83, to have a strong feeling of ownership towards the PROFILES project and believe in its rationale. Five teachers indicated, with a mean value less than 1,50, their willingness to continue and participate in the CPD programme. The low mean values (less than 2,00) of the total sample expressed the positive attitude of the questioned teachers towards the PROFILES modules, the CPD programme and the project rational (the first three categories).

The Self-efficacy Questionnaire, filled in by 27 teachers, indicates how much the participants feel that they are able and willing to use the project ideas and that they are not imposed on them (Katchevich, Hofstein, Yayon & Mamlok-Naaman, 2014). The results in Table 2 show that the mean values of the total sample in all four categories are, on a scale from 1 ("I cannot contribute anything") to 9 ("I can contribute a lot"), higher than 6,10 and therefore lie in upper half of the rating. With a mean value of the total sample of 6,90, the fourth category – that expresses the feeling of efficacy regarding the PROFILES project – is rated best.

Obviously 13 teachers (marked green) rate all four categories with mean values higher than 6,00 and can be labelled as "lead teachers." Especially four teachers (T1, T4, T8 and T21) indicate, with mean values over 8,00, very strong self-efficacy in inquiry teaching and towards the PROFILES project and therefore can be regarded as exemplary lead teachers. Only five teachers (T9, T11, T12, T20 and T23) rate their feeling of self-efficacy in almost all categories very low (mean values less than 5,00), of which two teachers (T9 and T20) surprisingly rate the fourth category (efficacy towards PROFILES) with mean values of 5.17 and 6,67, i.e much higher.

One of the investigated lead teachers conducted an action research case study on the implementation of a developed PROFILES module on the water cycle. The PROFILES module was evaluated (Draper, 1996; Powel, 2007) with two main questions:

1. How effective was the pedagogical intervention?
2. How did pupils react to the method of open inquiry teaching and what were the effects on the instruction?

The following methods were used to answer these questions:

a) interviews with pupils
b) questionnaire for pupils
c) class observation
d) reflections within the group of teachers (focus groups)

The results showed that the implementation of the PROFILES module „Where does our water come from?“ was successful. Pupils, as well as teachers, described the implementation positively. Pupils requested to have more lessons like this one. The initial worry of the teachers, that the pupils might be overburdened with the high degree of autonomy turned out to be unfounded. According to the interviews and focus groups, quite the contrary could be observed. Nethertheless it needed to be pointed out that the level of openness of the instruction must be adjusted to the level of knowledge and development of the pupils. Because every class was heterogeneous, this aspect might also be considered. Results of the focus groups show, that one group of pupils needed more support of the teacher e.g. to develop an own experiment. The same group could be highly motivated by the independent work, compared to regular lessons. During the phase of planning and conducting experiments pupils worked very focussed on their research experiments.

Teachers	Efficacy in student engagement	Efficacy in instructional strategies	Efficacy in inquiry teaching	Efficacy regarding PROFILES
T1	6,00	7,60	6,60	8,33
T2	6,75	7,60	6,40	6,83
T3	5,50	6,60	6,60	5,83
T4	7,00	7,80	8,20	8,67
T5	6,50	6,00	6,80	7,33
T6	5,75	6,20	5,60	6,83
T7	6,50	6,40	7,00	7,67
T8	7,75	7,80	8,00	8,50
T9	5,00	4,60	4,60	5,17
T10	7,25	6,40	5,80	6,83
T11	5,00	4,80	5,40	6,17
T12	4,50	5,00	5,20	5,33
T13	6,75	5,80	6,80	7,33
T14	7,50	5,40	5,00	6,50
T15	6,50	7,00	7,00	7,17
T16	6,50	6,80	6,60	7,00
T17	6,50	6,40	7,00	6,83
T18	5,00	6,25	6,60	7,33
T19	5,50	6,00	6,60	7,50
T20	4,33	5,40	5,80	6,67
T21	7,00	7,80	8,00	8,00
T22	7,00	7,60	7,60	7,83
T23	4,50	5,00	5,00	4,83
T24	6,25	6,20	6,20	6,50
T25	6,00	5,80	6,00	6,17
T26	6,75	6,60	7,00	6,67
T27	5,75	6,20	6,40	6,33
Total sample	6,12	6,34	6,44	6,90

1 = “I cannot contribute anything”; 9 = “I can contribute a lot”

Table 2. Self-efficacy means per person and category and for the total sample

Teachers saw this as a relief compared to regular lessons.

Questionnaire results show that pupils were motivated during the implementation of the module and that a positive learning effect can be observed. Pupils indicated to develop more self-confidence regarding their knowledge and competences. The most self-confidence pupils reached in the topics they examined intensely within the open inquiry method.

The development and implementation of the PROFILES module confirmed the teacher in the application of further innovative inquiry elements in his instruction. The successful implementation of the module was communicated among the teachers in the school and received a lot of interest.

Summary and outlook

The results of the ownership questionnaires and the action research study show that 11 lead teachers emerged from the Austrian PROFILES Community of Practice. These teachers might play an important role in the continuation of the CoP after the official end of the PROFILES project as interview data indicates. The CoP develops dynamically and the participating teachers organize themselves.

> *"I have no leading role anymore; it [the CoP] has become independent to a certain extent"* (coordinator of the Regional Science Network Vienna).

Because of its flexible character the CoP is open for new inputs and ideas that might change the focus of the community or the way it is working, but it will continue in an adapted form. The CoP already cooperates with other projects like KIP and PARRISE, where especially the practice of module development will be further developed.

Furthermore, the CoP includes the possibility to expand beyond the state of Vienna. By 2014 it already includes schools and teachers from Lower Austria. The first step towards the inclusion of Carinthia was made in 2013, by involving the coordinator of the IMST Regional Science Network Carinthia in the PROFILES Consortium Meeting that was held in Klagenfurt/Carinthia. He presented the IMST Network concept, showed some concrete examples and discussed his experiences with the PROFILES partners. Afterwards interested partners from Latvia were invited to an excursion where the coordinator explained the cooperation with the regional economy.

Summing up it can be said, that the aims of the Austrian PROFILES Network including 50 teachers in the CPD courses and developing over 10 lead teachers, were reached. An optimistic outlook shows, that these teachers as well as the activities and vital co-operations with the Regional Science Network Vienna will support a sustainable and dynamic continuity of the PROFILES Community in the future.

References

Draper, S. W. (1996). Integrative Evaluation: An Emerging Role for Classroom Studies of CAL. *Computers in Education, 26*(1–3), 17–32.

Galla, M., & Wenzl, I. (2013). *Anwendung von Open-Inquiry-Learning in einem PROFILES Modul. Case Study – Woher kommt unser Wasser?* Retrieved from: http://ius.uni-klu.ac.at/misc/profiles/files/Case%20Study_Galla-v2.pdf (25.06.2014).

Hildreth, P., Kimble, C., & Wright, P. (2000). Communities of Practice in the Distributed International Environment. *Journal of Knowledge Management, 4*(1), 27–38.

Hofstein, A., Mamlok-Naaman, R., Katchevitch, D., Rauch, F., & Namsone, D. (2012). Teachers' ownership: What is it and how is it developed? In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe – Reflections from the PROFILES Project* (pp. 56–58). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Katchevich, D., Hofstein, A., Yayon, M., & Mamlok-Naaman, R. (2014). From a CPD Workshop to the Development of self-efficacy and ownership among PROFILES teachers. The Israeli experience. In C. Bolte, J. Holbrook, R. Mamlok-Naaman, & F. Rauch (Eds.), *Science teachers'*

Continuous Professional Development in Europe. Case Studies from the PROFILES Project (pp. 197–207). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Powell, N. P. (2007). Seeding Enquiry-Based Learning in Electrical Electronic Enegineering: Optoelectrones. *International Conference on Engineering Education – ICEE*, 3–7.

PROFILES. (2010). www.profiles-project.eu (15.04.2014).

Rauch, F. (2013). Regional networks in education: a case study of an Austrian project. *Cambridge Journal of Education, 43(*3), 313–324.

Rauch, F., & Dulle, M. (2012). How to Involve Stakeholders in IBSE Networks. In C. Bolte, J. Holbrook & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 59–67). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Rauch, F., & Scherz, H. (2009). Regionale Netzwerke im Projekt IMST: Theoretisches Konzept und bisherige Erfahrungen am Beispiel des Netzwerks in der Steiermark. In K. Krainer, B. Hanfstingl, & S. Zehetmeier (Eds.), *Fragen zur Schule – Antworten aus Theorie und Praxis – Ergebnisse aus dem Projekt IMST* (pp. 273–286). Innsbruck: Studien Verlag.

Rauch, F., Dulle, M., Namsone, D., & Gorghiu, G. (2014). PROFILES Networks: Three International Examples. *Science Education International, 25*(2), 97–114. Retrieved from: https://www.dropbox.com/s/z785utt22k6gfqr/6-PROFILES%20Networks%20Three%20International%20Examples.pdf (27.06.2014).

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity.* Cambridge, U.K.; New York, N.Y.: Cambridge University Press.

Wenger, E., McDermott, R., & Snyder, W. (2002). *Cultivating Communities of Practice: A Guide to Managing Knowledge.* Harvard Business School Press, Cambridge, USA.

Wenzl, I. (2012). *Endbericht NAWI Netzwerk Wien.* Retrieved from: https://www.imst.ac.at/app/webroot/files/netzwerkprogramm/Endbericht_RN_Wien_2011_12.pdf (08.06.2014).

4.2 PROFILES – The Case of Cyprus: The Impact of a Participatory Design-model of Inquiry-based Learning Environments on Student Motivation

Yiannis Georgiou & Eleni A. Kyza – Cyprus University of Technology, Cyprus
Demetra Paraskeva-Hadjichambi, Zoe Kofina-Michael, Andreas Hadjistyllis & George Miliotis – Ministry of Education and Culture, Cyprus

Introduction

During the last decades, science education stakeholders have made several efforts to explore how to improve science teaching, since in most cases, science education fails to motivate or to meaningfully engage young learners (Eurydice Network, 2011). In many cases, traditional science education has been criticized for employing expository didactic approaches as well as focusing explicitly on teaching rote facts, without helping students to relate science to their own lives (e.g. Fensham, 2004; Holbrook, 2003). In an effort to address this problematic situation, a growing movement sees inquiry-based learning to be of paramount importance, since it has the potential to support students' active engagement with scientific practices such as the investigation of important societal issues (Eurydice network, 2011; NRC, 2012). If one purpose of science education is to produce students, who can be actively engaged with science, then inquiry-based learning environments can provide an ideal venue for the accomplishment of this goal.

The PROFILES Project

PROFILES is a four-year European project aiming to contribute to the mitigation of this situation by promoting scientific literacy through inquiry-based learning and education through science teaching. In order to do so, in-service science teachers, who participated in the PROFILES Cyprus professional development programme during the last three years, were involved in a participatory design process. According to this process, science teachers were asked to collaboratively design and implement an inquiry-based module in their classrooms. We detail the process of engaging local PROFILES teachers in participatory design and describe the inquiry-based learning environments they designed during 2013–14, in an effort to investigate the impact of the designed modules on students' motivation.

Methodology

Participatory design

Participatory design took a central role in PROFILES Cyprus, in an effort to actively involve science teachers in the development of inquiry-based modules that could be more aligned with their students' needs and interests. In this context, all of the science teachers who participated in the PROFILES Cyprus local network during 2013–14 were asked to join one of the groups, organized according to the following four disciplines: Biology, Middle School Chemistry, High School Chemistry, and Elementary School Science Education. They were then involved in a design-based process in order to develop innovative curriculum materials, based on the philosophy of inquiry-based teaching and learning. As a result, during the 2013–2014 school year, the four disciplinary groups developed and implemented four inquiry-based modules based on the PROFILES "Education through Science" approach (Holbrook & Rannikmäe, 2007).

Inquiry-based learning environments

All of the modules developed, integrated the PROFILES philosophy since (i) they were based on an authentic scenario related to students' lives, (ii) they actively involved students with inquiry-based investigations, (iii) they engaged students in a decision-making process asking them to take an evidenced-based stance.

More specifically, the four PROFILES learning environments developed and implemented during 2013–14 were:

- *"The Cypriots as climatic refugees: A fictional scenario or a forthcoming reality?"* developed by secondary biology teachers to motivate students' interest to learn about the carbon cycle.
- *"Nicolas and Anne want to exercise. Can they?"* developed by elementary school science teachers to motivate students' interest to learn about the circulatory system.

	Signed Ranks	N	Mean Rank	Sum of Ranks	*Z* value	Significance level
Students' motivation in Biology Education	*Negative Ranks*	7	18.93	132.50	-7.487	0.000
	Positive Ranks	79	45.68	3608.50		
	Ties	0				
Students' motivation in Elementary Science Education	*Negative Ranks*	2	4.00	8.00	-5.479	0.000
	Positive Ranks	39	21.87	853.00		
	Ties	2				
Students' motivation in Middle School Chemistry	*Negative Ranks*	1	1.50	1.50	-4.060	0.000
	Positive Ranks	21	11.98	251.50		
	Ties	0				
Students' motivation in High School Chemistry	*Negative Ranks*	4	7.25	29.00	-3.009	0.003
	Positive Ranks	17	11.88	202.00		
	Ties	0				

Table 1. MoLE Results: Comparing Students' Views about an „Ideal" versus a „Real" Science Lesson

- *"Robbery at the jewellry shop: Innocent or guilty?"* developed by middle school chemistry teachers to motivate students' interest to learn about the metals reactivity.
- *"What water to drink to quench my thirst?"* developed by high school chemistry teachers to motivate students' interest to learn about water composition and quality.

Classroom implementations

The four modules were implemented by most of the science teachers who participated in PROFILES 2013–14. This study focuses on a total of 177 students (102 girls and 75 boys) as follows:

- Biology education classroom enactments: 88 middle school students (four intact classes).
- Elementary school science education classroom enactments: 45 elementary school students (two intact classes).
- Middle school chemistry education classroom enactments: 22 middle school students (two intact classes).
- Lyceum chemistry education classroom enactments: 22 high school students (two intact classes).

These students compose a sub-sample from the sample of the total students, who participated in PROFILES implementations during 2013–14. They were selected since they had completed the MoLE survey (Bolte, 2000) both before and after the learning intervention.

Data collection and analysis

Quantitative data were collected by students through the MoLE motivation survey (Bolte, 2000) that was universally employed by all PROFILES partners. The survey consists of three different versions. The REAL version was administered before the teaching intervention and collected students' views of traditional science lessons. The IDEAL version was also administered before the intervention and collected students' views about an ideal science lesson. Finally, the INQUIRY version was administered after the intervention and collected students' views about the inquiry-based learning environments implemented. Thus, the aim of the questionnaire was to examine student motivation gains, after their participation in the inquiry-based learning environments, by comparing the three versions. The Wilcoxon signed-rank test was employed to analyze the quantitative data derived from MoLE survey comparing the different versions of the survey (Real, Ideal, Inquiry).

Results

REAL vs IDEAL version

Table 1 compares students' answers regarding a real and an ideal science lesson. As indicated in Table 1, all students found their current lessons as less motivating when compared with their ideal lessons. As students results indicate, they prefer to enjoy and to understand the lessons more, to have more time to think before providing answers to questions, to have more opportunities to make suggestions as well as ask questions, to invest more effort to understand, to participate more, to collaborate to a greater extent with other students and be taught about issues that are relevant to their daily lives and the society in general.

REAL vs INQUIRY version

As presented in Table 2, the comparison of students' responses regarding their normal teaching contexts and the PROFILES inquiry lessons indicated that most of the students who participated in the PROFILES learning interventions, expressed that the inquiry-based lesson significantly motivated them and increased their interest in learning in science. More specifically, this comparison revealed that students understood and enjoyed the inquiry-based lesson more than they had previously enjoyed traditional ones, they had more time to think before answering a question, they had more opportunities to make suggestions and questions, they invested more effort, they participated more, they collaborated to a greater extent with the other students and they were taught about issues that were more relevant to them.

	Signed Ranks	N	Mean Rank	Sum of Ranks	Z value	Significance level
Students' motivation in Biology Education	*Negative Ranks*	23	26.93	619.50	-4.593	0.000
	Positive Ranks	55	44.75	2461.50		
	Ties	10				
Students' motivation in Elementary Science Education	*Negative Ranks*	10	14.25	142.50	-3.735	0.000
	Positive Ranks	31	23.18	718.50		
	Ties	0				
Students' motivation in Middle School Chemistry	*Negative Ranks*	2	11.25	22.50	-3.241	0.001
	Positive Ranks	19	10.97	208.50		
	Ties	1				
Students' motivation in High School Chemistry	*Negative Ranks*	1	1.50	1.50	-3.443	0.001
	Positive Ranks	15	8.97	134.50		
	Ties	2				

Table 2. MoLE Results: Comparing Students‘ Views about an „Inquiry“ versus a „Real“ Science Lesson

Discussion

At a time of continued dissatisfaction with the state of science education in many parts of the world, science education stakeholders are investigating ways to promote students' appreciation of the nature of science, improve the quality of learning, and establish science learning as a meaningful and motivating activity. However, according to Bolte and Streller (2011) this will not happen if science education is not meaningful for students, if students cannot relate what they are taught with their lives and if instruction does not motivate them.

As presented in this study, the analysis of the MoLE motivation survey administered to the students before and after the PROFILES inquiry-based interventions in Cyprus yielded statistically significant results for all inquiry-based implementations, suggesting that the approach taken by the Cyprus PROFILES team was successful in reaching, at least, some of its major goals: increasing and sustaining students' motivation through scenarios relevant to their lives, and actively engaging them in learning science. In this context, the findings of the present study create a sense of optimism since students, who were taught with the PROFILES-based learning environments, revealed a great desire of involvement with the learning process and found the instructional context more meaningful and motivational.

References

Bolte, C. (2000). *Enhancing students' motivation and ability to communicate in chemistry class-discourse*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (NARST), New Orleans, Lousiana, USA.

Bolte, C., & Streller, S. (2011). Evaluating students' gains in the PROFILES project. Proceedings of the 9th International Conference of the European Science Education Research Association (ESERA2011) Biannual Conference.

Eurydice Network. (2011). *Science in Europe: National policies, practices and research*. Brussels: Education, Audiovisual and Culture Executive Agency. doi: 10.2797/7170

Fensham, P. J. (2004). Increasing the relevance of science and technology education for all students in the 21st century. *Science Education International, 15*(1), 7–26.

Holbrook, J. (2003). The way forward. *Science Education International, 14*(1), 5–13.

Holbrook, J., & Rannikmäe, M. (2007). The Nature of Science Education for Enhancing Scientific Literacy. *International Journal of Science Education, 29*(11), 1347–1362.

National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press.

4.3 Continuous Professional Development and Teachers' Development of Ownership of Inquiry: The Case of PROFILES Cyprus

Eleni A. Kyza & Yiannis Georgiou – Cyprus University of Technology, Cyprus

Introduction

Teacher ownership of inquiry (IBSE) as an approach to teaching and learning science is pre-requisite to the success of educational reform (e.g. Brown & Campione, 1996; Fullan, 2007; Pintó, 2005). Rannikmäe (2005), drawing from data from a study of 20 teachers, argued that, even though there are different types of ownership, they all lead to a better conceptualization of the learning environment; as a result she concluded that the development of ownership can support teachers in assuming the new roles required in effective reforms.

Kirk and MacDonald's (2001) work provided evidence in support of a situated cognition approach to developing ownership and emphasized that the extent to which ownership develops is influenced by the power relationships, the control and the authority attributed to the teacher. The PROFILES approach of continuous professional development (CPD) addresses such concerns and provides opportunities to teachers to have their voices heard while learning about and appropriating inquiry in their practice.

The goal of PROFILES is to build local and transnational teacher networks of practice, providing teachers with the opportunity to enrich their scientific knowledge background (teachers as learners), to design and implement PROFILES modules in their classrooms (teachers as teachers), to reflect on their experiences and to participate in reflective activities or action research (teachers as reflective practitioners) and to illustrate ownership and disseminate the PROFILES pedagogy to their colleagues and other relevant stakeholders (teachers as leaders). These four dimensions can also be seen as constituents of the PROFILES model to develop ownership towards IBSE (Blonder, Mamlok-Naaman & Hofstein, 2007).

The goal of this contribution is to summarize the development of the PROFILES Cyprus teachers' IBSE ownership in terms of the four-aspect model of developing teachers' ownership: (a) teachers as learners, (b) teachers as teachers, (c) teachers as reflective practitioners and (d) teachers as leaders. We next present a brief synopsis of our findings regarding each of these four dimensions during the PROFILES continuous professional development programme which unfolded over a period of three years (2011–2014).

The PROFILES CPD and teachers' professional development

The contribution of the CPD approach to developing teachers' ownership was evaluated, employing a repertoire of different approaches such as: questionnaires about teachers' ownership of the inquiry approach, interviews with teachers or questionnaires regarding the participatory design approach.

Our findings indicated a gradual increase of teachers' sense of ownership towards IBSE. For instance, a questionnaire including a radial diagram (adapted from the Weizmann Institute) was completed by 15 of our science teachers at the end of PROFILES 2012–13. The aim of the questionnaire was to investigate the different aspects of our local project that promoted teachers' ownership, by asking the teachers to indicate and rate the six main aspects that influenced their sense of ownership. The different aspects that our teachers mentioned were grouped and classified in broader themes (Table 1), following a content analysis approach as suggested by Patton (2002). In addition, the frequency of each issue, as well as the mean value from teachers' assessment, was also estimated. The analysis of teachers' diagrams indicated that our teachers developed a high sense of ownership towards PROFILES and its inquiry-based philosophy (see for example Figure 1).

As teachers explained and as indicated in Table 1, their ownership towards IBSE increased. The project gave them the opportunity to increase their self-efficacy in several aspects due to a) their participation in a number of workshops and training seminars, b) the participatory design employed, and c) due to the implementations of the inquiry-based learning environments they employed in their classrooms.

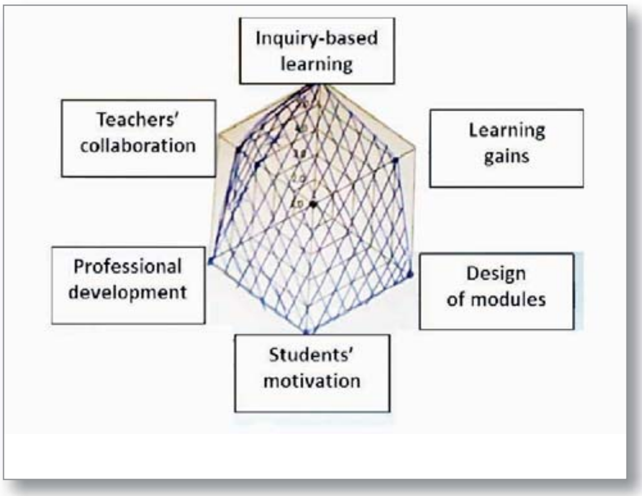


Figure 1. Teachers' evaluations of their sense of ownership

Teachers as learners

The goals of the local CPD programme were to address the teacher identified needs as those were identified by them at the outset of the CPD. As a result, the main emphases of the CPD were to support teachers' growing understanding of inquiry-based pedagogy, their capacity to design reform-based curricula, and help them understand how to best integrate technology in their inquiry

Themes	Aspects of CPD indicated as important	N	Mean
Workshops & Training seminars	Continuous professional development	12	5.3
	Student-centred learning	8	6.0
	Interdisciplinarity	8	3.9
	Integration of new technologies	8	3.0
	Inquiry-based learning	4	5.8
	Develop of an educational philosophy	3	6.0
Participatory design	Teachers' collaboration/interactions	8	6.0
	Involvement in the design of modules	7	5.7
	Development of professional/interpersonal relationships	3	5.3
	Improvement of designing skills	3	4.3
Inquiry-based implementations	Increase of students' motivation	12	5.2
	Increase of students' learning gains	7	5.3
	Improvement of science teaching	4	4.7
	Action research and reflection	3	5.0

Table 1. Analysis of the main themes and issues that had a positive impact on PROFILES teachers' ownership

lessons. No separate courses were offered for developing science content understanding; however, the teachers delved deeper into subject matter learning in the area of their curriculum design and in the context of participatory and collaborative design.

Teachers as teachers

In an initial survey completed at the outset of the CPD in 2011 over 65% of the teachers (n=38) indicated that they needed to learn about IBSE. Based on the responses we received, we organized three cycles of Continuous Professional Development (CPD) programmes during 2011–14. A total of 41 science teachers (Biologists, Chemists, Physicists, Primary science education teachers) participated in training seminars and workshops focusing on issues which the teachers had indicated as areas of learning, such as: computer-supported collaborative inquiry, field-based inquiry, reflective inquiry, technology in support of learning, etc.

Just-in-time learning also took place in the context of informal activities, as a result of teachers' participation in participatory design (Kyza & Nicolaidou, 2011) of technology-supported, inquiry-based modules. Teachers worked in disciplinary groups (Biology, Chemistry, Elementary School Science) for an extended period of time to iteratively develop web-based, data-rich investigations with the goal to motivate students and support their conceptual understanding of the socio-scientific concepts addressed in each module.

Beginning with the assumption that learning is situated, we designed the CPD programme with the expectation that the learning environments, which teachers designed, would also be enacted in real-world contexts. This application would allow teachers to engage in workplace learning, support their understanding of the pedagogical and instructional implications of IBSE, and, as a consequence, contribute to their ownership. To assess the effectiveness of the approach on students, we collected research data on students' motivation, using the MoLE questionnaire (Bolte, 2000), administered before and after each implementation. The analysis of the results indicated that the enactments had a statistically significant positive impact on the increase of students' motivation when compared to students' motivation in more traditional settings.

Teachers as reflective practitioners

While being an effective science teacher can serve as an indicator of teacher ownership, according to the PROFILES project the ability to reflect back on one's practice critically is a powerful indicator of ownership.

In this context, a multiple case-study (Georgiou & Kyza, 2013; Kyza & Georgiou, 2013) examined two PROFILES teachers practice and reflections. Data collected included videos of the science teachers' classroom enactments and reflective, post-lesson interviews with each one of these teachers.

These case studies revealed that there was a gradual increase of the science teachers' ownership during the enactment, in terms of: (a) personal beliefs, (b) outcomes efficacy, (c) self-identity, (d) belongingness and (e) sustained interest about the inquiry-based approach. This increase also appears to have impacted the science teachers' practice, since there was a gradual shift from regulative discourse (e.g. procedural talk, technical talk) to instructional discourse (e.g. framing the task, encouraging sense-making, supporting the development of arguments). As the science teachers indicated, reflecting on their own practice was of paramount importance in terms of realizing what did not work well during their teaching, and providing them with the opportunity to address these issues in the next lessons.

Teachers as leaders

Last but not least, according to the PROFILES project, as science teachers develop a sense of ownership towards PROFILES, they gradually transform into leaders in the field of science education. This leadership is shown not only in the teachers' intention to integrate inquiry-based approaches in their science classrooms, but also in their efforts to disseminate the approach within new and existing educational networks.

In this context, the science teachers, who participated in PROFILES Cyprus during the last three years, have undertaken a considerable variety of disseminating activities, aiming to promote the PROFILES ideas. For instance, the local PROFILES teachers undertook activities such as:

- Representation of the first PROFILES science teachers' network in Cyprus at the first PROFILES European conference in Berlin, with the aim of disseminating the local inquiry-based modules.
- Self-initiated participation and distinction of the Chemistry teacher group in the competition "Science on Stage Cyprus" and "Science on Stage Europe".
- Submissions of posters and papers at local or international conferences by the science teachers who participated in PROFILES Cyprus (e.g. ICEM 2012, ESERA 2013, 2nd and 3rd Pancyprian Conference of Student-Teachers for the Natural Sciences, taking place in Cyprus, Athens, Belgium, Germany, Israel, etc.).
- Organization of training seminars and presentations to fellow teachers in their schools.
- Publishing articles and announcements on school websites.
- Organizing joint classes for students at different levels of education (e.g. primary and secondary school students).

Concluding remarks

The present contribution has presented an overview of the development of the PROFILES Cyprus teacher network's sense of ownership towards IBSE during the last three years. Following the PROFILES ownership model, we provided teachers with opportunities to enrich their pedagogical background about IBSE (Teachers as learners), to design and to implement IBSE modules into their classrooms (Teachers as teachers), to reflect on their experiences and to participate in action research (Teachers as reflective practitioners) and to disseminate the philosophy and ideas to their colleagues and other relevant stakeholders (Teachers as leaders). Based on the data collected, which we were, unfortunately, not able to present in detail here due to space limitations, the approach of PROFILES Cyprus was successful in helping the PROFILES teachers develop their sense of ownership of IBSE and become agents of change themselves.

References

Blonder, R., Mamlok-Naaman, R., & Hofstein, A. (2008). Increasing Science Teachers ownership through the adaptation of the PARSEL modules: A "bottom-up" approach, *Science Education International, 19*(3), 285–301.

Bolte, C. (2000). *Enhancing students' motivation and ability to communicate in chemistry class-discourse*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (NARST), New Orleans, Louisiana, USA.

Brown, A., & Campione, J. (1996). Psychological theory and the design of innovative learning environments: On procedures, principles, and systems. In L. Schauble & R. Glaser (Eds.), *Innovations in learning: New environments for education* (pp. 289–325). Mahwah, NJ: Lawrence Erlbaum Associates.

Fullan, M. (2007). *The new meaning of educational change* (4 ed.). New York: Teachers College Press.

Georgiou., Y., & Kyza, E. A. (2013). *Science teachers' ownership of the inquiry-based approach: An elusive idea or a concrete construct?* Paper presented at the 10th Conference of European Science Education Research Association (ESERA 2013), Nicosia, Cyprus.

Kirk, D., & Macdonald, D. (2001). Teacher voice and ownership of curriculum change. *Journal of Curriculum Studies, 33*(5), 551–567.

Kyza, E. A., & Georgiou, Y. (2013). *Operationalizing teachers' psychological ownership of reform curricula.* Paper presented at the 15th Conference of European Association for Research on Learning and Instruction (EARLI 2013), Munich,

Germany.
Kyza, E. A., & Nicolaidou, I. (2011). Participatory Design for Effective Web-based Learning Environments. *Proceedings of EARLI 2011 14th Biennial Meeting*, August 30 – September 3, 2011, Exeter, U.K.
Patton, M. Q. (2002). *Qualitative research and evaluation methods*. London: Sage.
Pintó, R. (2005). Introducing curriculum innovations in science: Identifying teachers' transformations and the design of related teacher education. *Science Education, 89*(1), 1–12.
Ranninkmäe, M. (2005). Promoting Science Teacher Ownership through STL Teaching. *APFSLT, 6*(1).

4.4 Development of Giftedness within PROFILES

Josef Trna & Eva Trnova – Masaryk University, Brno, Czech Republic

Abstract

The study presents our research results on the development of gifted students in science by the use of inquiry-based science education (IBSE). IBSE seems to be the appropriate educational method for the development of giftedness. For gifted students, some components of IBSE must be selected and modified. IBSE matches the special educational needs of gifted students, because it corresponds with their specific behaviour. The main objective of our research was to find out which components of IBSE are suitable for the development of gifted students. The core research method used in this study is design-based research consisting of four steps. School environment is the main factor in the realization of the development of giftedness. The role of science teachers in development of gifted students is irreplaceable. The IBSE components for gifted students are a very important part of teachers' continuous professional development (CPD). Teachers need teaching and learning materials for the development of gifted students. IBSE experiments are presented in the role of very important developmental instrument for gifted students. The learning task with an IBSE experiment from the module "Safe swimming and diving" is presented. Our research outcomes have been created within the European project PROFILES, which supports science teachers in their use of IBSE.

Introduction

Strong support for gifted students in science is an important educational strategy in developed countries. This support enables gifted students to establishment themselves in society and in the labour market. Mönks and Ypenburg (2002) argue that about 2–3 % of students are exceptionally gifted i.e. talented. However, in very good conditions the rate of students excelling in some areas might increase up to 20–25 % (Freeman, 2010). Wide support of students gifted in science is now a social necessity. IBSE is an accepted teaching and learning strategy for this support.

Theoretical frameworks

Renzulli (1986) created a three-ring model for determining aspects for the development of giftedness: creativity + ability + motivation (called task commitment). Mönks and Ypenburg (2002) modified Renzulli's model and added supportive environment. All educational experts state that the development of giftedness depends especially on a supportive environment.

Crucial areas for the support of gifted students (Trnova & Trna, 2012) are:

(a) Education of teachers for identifying and supporting giftedness
(b) Creation of a supporting system to help teachers and families in the education of gifted students

(c) Setting up of high-quality school facilities for gifted students

We will focus on the support of teachers for the education of gifted students in the frame of the PROFILES CPD.

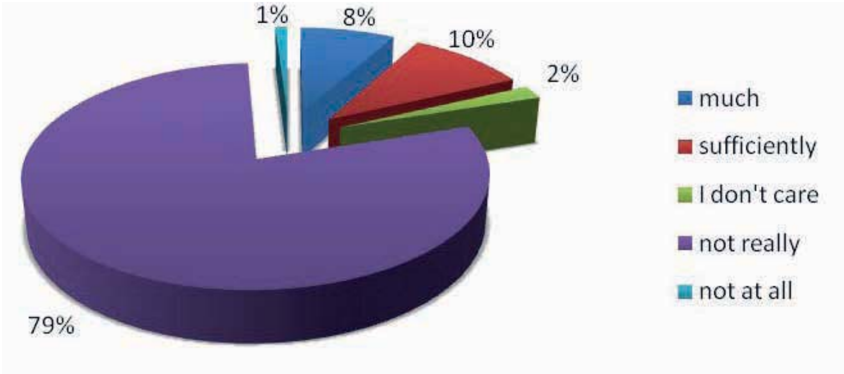


Figure 1. Frequency of responses to question 1

Which activities would you like to do in class; which activities interest and attract you?	Gifted students N=15
Experimentation	100 %
Measurement	93 %
Identifying the fundamental processes in nature	93 %
Observation	93 %
Analyzing phenomena	87 %
Expressing an opinion and defending it	87 %
Solving projects	80 %
Substantiation of solutions	80 %
Formulating conclusions	73 %
Describing phenomena	73 %
Verification of hypotheses	67 %
Data processing	67 %
Creating hypotheses	60 %
Evaluation	53 %

Table 1. Specific educational needs of students gifted in science

Research question and methods

For our research objectives and research question a design-based research approach was used (Reeves, 2006). The main advantage of design-based research is its close connection with school practice and its focus on the development of new curricular and CPD materials. We also used other research methods/tools within the design-based research: questionnaires, interviews, portfolios etc. Our design-based research consisted of four steps:

(1) Analysis of practical problems:
We identified the existing educational problems in the development of students gifted in science through using methods of observation, students' questionnaires etc. Our research question was formulated as follows:

Which IBSE components are effective for the development of students gifted in science and also important for inclusion in science teacher's CPD?

(2) Development of solutions with a theoretical framework:
We have compared the specific educational needs of gifted students and the IBSE components. On the basis of this comparison, we upgraded IBSE modules within the project PROFILES to be suitable for gifted students.

(3) Evaluation and testing of solutions in practice:
Science teachers (participants in the PROFILES project), as the authorised implementers and evaluators of the PROFILES modules, used action research for testing of components for gifted students.

<table>
<tr><th>Educational needs</th><th>IBSE components</th></tr>
<tr><td>Observation; experimentation</td><td rowspan="3">Inquiry: observation, experimentation, building apparatus, measurement, collection and evaluation of data; finding and checking and the importance of information (with the help of inquiry); development of conception; evaluation of pre-conceptions; the use of ICT</td></tr>
<tr><td>Measurement; data processing</td></tr>
<tr><td>Analyzing phenomena; identifying the fundamental processes in nature; describing phenomena</td></tr>
<tr><td>Creating hypotheses; verification of hypotheses; evaluation</td><td rowspan="2">Logical thinking, interconnection of facts, drawing conclusions (not only to memorize facts); implementation of own innovative solutions (not only to follow instructions blindly), argumentation, communication.</td></tr>
<tr><td>Formulating conclusions; expressing opinions and defending them; substantiation of solutions</td></tr>
<tr><td>Solving projects</td><td>Suitable contents from everyday life; interdisciplinary nature of problems; using evidence gained from a range of information sources; understanding of science concepts through the students’ own activity and reasoning.</td></tr>
<tr><td rowspan="3"></td><td>Student = active researcher</td></tr>
<tr><td>Teacher = adviser and guide.</td></tr>
<tr><td>Working in groups, cooperation, and discussion.</td></tr>
</table>

Table 2. Comparison of educational needs and IBSE components

(4) Documentation and reflection to produce “Design principles”:
The final stage was the documentation and the establishment of design principles in the form of suitable IBSE components for students gifted in science.

Findings

Our design-based research brought many findings about development of gifted students. This study presents only the part corresponding to the above research question.

Analysis of practical problems

We determined gifted students’ opinions about their motivation in instruction using a questionnaire. Our questionnaire (2011/2012) was distributed to 86 gifted students (aged 16 to 18) in the Czech Republic (Trnova, Trna & Skrabankova, 2013). One of the most significant items is given below:

Question No. 1: *Does your school environment motivate you to study physics?*

The questionnaire analysis has shown that the current situation in the motivation of gifted students is unsatisfactory.

Development of solutions with a theoretical framework

This step of our design-based research was investigating the specific educational needs of gifted students. In the year 2011, we distributed a questionnaire to a representative sample of 15 students aged 15–18 from upper secondary schools who were gifted in science (Trnova & Trna, 2012). Their giftedness was verified by a specialist pedagogical-psychological board and by the declaration of their teachers.

We present (see Table 1) a part of the questionnaire results: a list of specific educational needs of gifted students indicated by more than 50 %.

The questionnaire research produces the findings that gifted students in science have specific educational needs in comparison with non-gifted students (Trnova & Trna, 2012). We cannot generalise these results because of the low number of gifted students.

We compared the specific educational needs of gifted students and IBSE components (see Table 2).

The IBSE components for gifted students should be modified according to their educational needs. We have found that there are IBSE components which correspond to the educational needs of gifted students. We have developed these special elements of PROFILES modules.

Evaluation and testing of solutions in practice

The PROFILES modules with the components for gifted students were validated in the years 2012–2013 by fifty teachers in fifty classrooms in the Czech Republic during PROFILES CPD. In these classes, 45 students gifted in science were present.

As an example, here is the most popular IBSE component – experiment, which has a decisive role in science education (Trna & Trnova, 2012). The developmental role of experiments for gifted students is in line with the importance of experiments in science research (Trna, 2012) and the cognitive importance of experiments in science education (Haury & Rillero, 1994). We present as an example a learning task with an experiment (the fourth open level) from the module: "Safe swimming and diving."

An overpressurized bottle: Compression of the lung

Task: Experiments using a vacuum pump are often demonstrated. Create a mechanism that demonstrates an additional phenomenon under high pressure. How would this phenomenon manifest itself in the human organ of breathing?

- Inflate a rubber balloon inside a plastic bottle (see Figure 2).
- Higher pressure in the bottle produced by the pump induced reduction in volume of the balloon (see Figure 3).
- After opening the bottle, the balloon again increases its volume (see Figure 4).

Figure 2. A balloon in the non-pressurized plastic bottle

Figure 3. The balloon in the pressurized plastic bottle

A decision-making (solution) by a gifted student:

- Deformational effect from pressure is demonstrated by the reduced volume of an inflated rubber balloon.
- The pressure under water during diving reduces the lung volume. We are able to breathe only about one metre under the water surface. At a depth of ten metres the lung volume is reduced to half. Therefore to be able to continue breathing, air must be

pumped into the lungs of a diver by pressure during diving. If in this case the diver emerges from depth without breathing, his lungs can be fatally damaged by the expanding air, resulting in burst lungs and death.

Figure 4. The balloon in the non-pressurized plastic bottle

Documentation and reflection to produce "Design principles"

The outcomes of our design-based research are IBSE components which broaden the IBSE approach in the field of education of gifted students:

- Emphasis on a very active role for gifted students
- Individual approach to gifted students with great teacher empathy
- Encourage students to undertake problem-solving
- Implementation of scientific ways of working (analyzing phenomena, verification of hypotheses, development of experimental devices, etc.)
- Use of experimentation and practical problem tasks (projects)
- Supporting connectivistic tasks (net-system gaining of information)

Implementation of these "design principles" supports the development of gifted students. This approach matches the special educational needs of gifted students.

Conclusion and Prospects

Our research has added new dimension into PROFILES implementation of IBSE and CPD. This pilot research suggested the importance of IBSE as a developmental method for gifted students in science.

Teachers need special methods and tools for education of gifted students. These methods should be implemented into pre-service and in-service science teacher education (Trnova, 2012). We used as a one way in which these ideas can be disseminated to teachers is through PROFILES CPD. We modified our PROFILES modules and implemented our research outcomes into PROFILES CPD.

References

Freeman, J. (2010). *Gifted Lives: What Happens when Gifted Children Grow Up*. New York: Routledge Chapman and Hall.

Haury, D. L., & Rillero, P. (1994). *Perspectives of Hands-On Science Teaching.* Columbus: ERIC-CSMEE.

Monks, F. J., & Ypenburg, I. H. (2002). *Nadané dítě.* Praha: Grada Publishing.

Reeves, T. C. (2006). Design research from the technology perspective. In J. V. Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), *Educational design research* (pp. 86–109). London, UK: Routledge.

Renzulli, J. S. (1986). The three-ring conception of giftedness: a developmental model for creative productivity. In R.J. Sternberg & J. E. Davison (Eds.), *Conception of giftedness* (pp. 53–92). Cambridge, UK: Cambridge univ. press.

Trna, J. (2012). How to motivate science teachers to use science experiments. *Journal of Systemics, Cybernetics and Informatics, 10*(5), 33–35.

Trna, J., & Trnova, E. (2012). Inquiry-based Science Education Experiments. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 212–215). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria)

Trnova, E. (2012). Teacher Development in IBSE. In *Badania w dydaktyce chemii* (pp. 181–184). Krakow, Poland: Pedagogical University of Krakow.

Trnova, E., & Trna, J. (2012). Development of Science and Technology Gifted Students through Inquiry-Based Science Education. In *Proceedings of the 8th International Conference on Education* (pp. 838–844). Samos, Greece: Research and Training Institute of East Aegean.

Trnova, E., Trna, J., & Skrabankova, J. (2013). Science Teacher Professional Development in Education of Gifted Students. *Journal of Educational and Instructional Studies in the World, 3*(2), 13–17.

4.5 Initial Results from PROFILES in Denmark

Klavs Fridahl, Lærke Bang Jacobsen & Jan Alexis Nielsen – University of Copenhagen, Denmark

Abstract

The University of Copenhagen joined the PROFILES project in November 2013. The scope for the Copenhagen team is to contribute to all work packages of the PROFILES project. In this paper we'll describe what we currently are doing for the WP3, WP4 and WP5. In particular, this paper presents the results from the second Delphi round in Denmark.

The Delphi Study

Currently we are in the process of finishing the second round of the National PROFILES Curricular Delphi Study (Schulte & Bolte, 2012; 2014). Results are still coming in on the second round, but we have some preliminary results that are quite interesting. Since more than 50% of the responses are from science teachers, we believe that the results are relevant when related to topics taught in Danish upper secondary schools even though the sample is still very small.

Figure 1 shows the list of the top ten categories rated by the stakeholders for the second round of the Delphi Study for the ideal teaching in science at Danish upper secondary schools (grade 10–12). It is interesting to notice that five of the ten categories listed as top priority clearly relate to Inquiry-based Science Education. These are: Critical approach to scientific information and data, scientific techniques and skills, Collecting and handling data, Experimentally-based science inquiry competence and finally Nature of Science. This supports the idea of the need for more focus on the skills and competences related to IBSE.

	Students	Science teachers	Industry/ scientists	Scientific education researchers/admin.	Total
1 Round					
# invitees	184 +	274 +	172	64	
2 Round					
# invitees	126	55	17	22	220
# respondents	12	38	8	11	69
%	10%	69%	47%	50%	31%

Table 1. National PROFILES Curricular Delphi Study

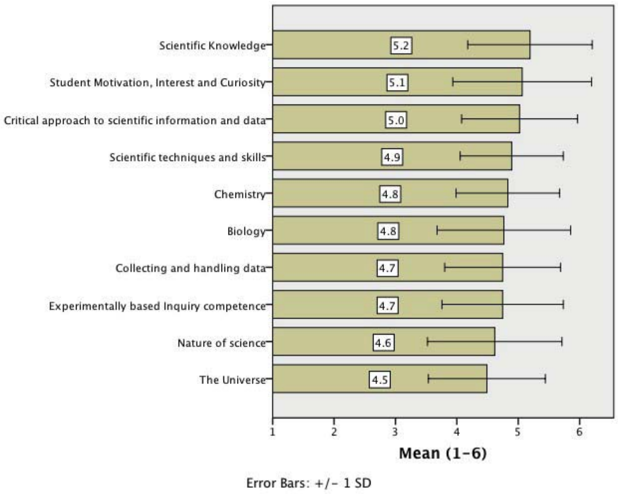


Figure 1. Top ten categories

Figure 2 lists the bottom ten categories rated by the stakeholders. Again it is interesting to notice that traditional socio-scientific issues such as Natural disasters, Increased complexity, Economic development in Denmark, Ethics and Sustainability are all rated as being among the least important categories for teaching. This puts an even more challenging focus on the Engage-phase of PROFILES teaching, since just having a socio-scientific focus does not alone ensure that the students engage in the learning process according to the stakeholders.

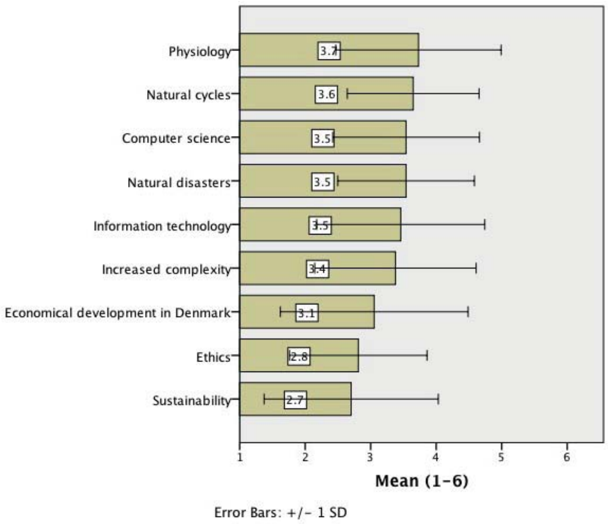


Figure 2. Bottom ten categories

Continuous Professional Development

Within WP5, we have been running three courses for science teachers at the upper secondary level in Danish schools. The first two courses were, due to time constraints, integrated into teacher professional development activities that fit with the PROFILES requirement of a longitudinal CPD intervention (Hofstein & Mamlok-Naaman, 2014; Hofstein, Katchevich, Mamlok-Naaman, Rauch & Namsone, 2012). The latest course specifically targeted the teaching of IBSE for the entire group of science teachers at a Danish upper secondary school.

Network of new science teachers at upper secondary schools

In December 2013, we finalized the first of our activities focusing on disseminating IBSE. Since this was the first course, we integrated the teaching on IBSE into another course that focused on creating a network of teachers to support teachers in their first years of teaching so that they, on the one hand, would get an easier start in the teaching profession and on the other hand, maintain the ideas and visions about teaching in their subjects and at the same time, through exchanges of experience, would become familiar with how to make the transition from being scientist to becoming a teacher of science.

The course had 20 participants from 10 different schools. four meetings were scheduled in the network, and the idea was that groups should be formed and these groups would meet between meetings. Each meeting had a special theme. The intention of the networking was that the groups were to continue meeting after the course (Rauch & Dulle, 2012; 2014). The participants assessed an overall need for networks of this type, but at the same time they noted that there is “very little,” or “little” time to participate in such a network. It confirms our belief that new teachers are very busy and do not have time to participate in further activities. The goal of the network is, of course, also to facilitate the everyday life of the participants, but it is probably not happening to any significant extent.

Danish Science Schools

A large number of Danish upper secondary schools are members of the organisation, Danish Science Upper Secondary Schools (DASG). The purpose of this organisation is (among other things) to

> *"develop new teaching and learning methods and new teaching materials on the basis of didactic research and new professional educational ideas . . . and to support teachers' skills through courses, seminars and conferences"*(http://science-gym.dk/).

In 2013–2014, this organisation ran a course on Inquiry-based Science Education and Green Technology. Approximately 25 teachers from the participating upper secondary schools attended the course. The scope of the course was to visit a range of green technology projects so as to offer some on-site experience to the teachers attending the course and secondly to develop teaching materials for teachers to use in their classes when teaching on green technology subjects using an IBSE approach. The University of Copenhagen was involved in planning and running the IBSE focus in this course.

Summary on teacher experiences from the first two courses

Interviews were conducted with some of the attending teachers on these courses related to their experiences on the course and their experiences when working with the classes they teach at their home schools, using an IBSE approach to science teaching.

This note is a summary from these interviews. The findings are categorised under four headings:

- What are the *problems* seen by the teachers when using an IBSE approach when teaching science at the upper secondary level?
- What are the *challenges* when teaching the IBSE way?
- What are the *advantages* obtained when teaching using IBSE in science teaching?
- What do the teachers find are the keys to *success* in IBSE based science teaching?

Problems

Listed here are the problems mentioned by the science teachers in the interviews related to IBSE based teaching:

- Teaching using the IBSE approach reduces science to inquiry. But science is more than just inquiry.
- The IBSE approach is very time consuming and takes time from other ways of teaching.
- It is impossible for students to do experiments on some topics in science. One example is Plate Tectonics.
- For some teachers, it is hard to allow the students to take the lead in class and to let them design and carry out experiments not planned and tested by the teacher.

Challenges

Listed here are the challenges mentioned by the science teachers in these interviews on IBSE based teaching:

- When using the 6F (the Danish version of the 5E model) the "Fang" (equals Engage) step is hard. Furthermore, it is critical to the success of the following phases and does not necessarily engage all students.
- IBSE is hard for the students. It requires a change in the contract between student and teacher regarding the role of the two parties. Who's responsible for what? The students expect the teacher to be responsible for teaching and making sure that the students are learning. It is not enough for the teacher just to facilitate.
- Students need to learn to do IBSE. It requires training.
- 6F (or 5E) and IBSE has a built in dilemma. To be successful, IBSE approaches need to be practiced over and over again. But then again, this may be boring for the students to do the same over and over again.
- In the first phases of an IBSE course, the

teacher will encourage the students to investigate and suggest solutions to their problems. However, at the end of the course the teacher may need to tell the students that their conclusions to their experiments and their answers to their hypotheses are wrong. We, as teachers, are forced to take on another role as "judges". This role differs from the role of guide and consultant in the first phases of the course. A new role that we have refused to fill during the entire course. It changes the role of the teacher.

Advantages

Listed here are the advantages mentioned by the science teachers in these interviews on IBSE based teaching:

- Not all students possess the same skills. The IBSE approach allows students to form groups that reflect the skills and the level of ambitions of the students thus allowing for a differentiated teaching environment.
- Based on experience, if the students are actually engaged, they can solve the challenges and successfully undertake IBSE.
- Also based on experience, there is time enough in science classed to do IBSE.
- One (additional) reason for doing IBSE is that the students will develop additional skills on top of their basic science training. They do develop the "meta-skills" side by side with their science knowledge.
- IBSE is not just about making experiments. IBSE is also searching for information in textbooks, YouTube videos, Ted Talks, graphs, tables, etc. It allows for a great deal of flexibility.
- IBSE does not mean that you, as a teacher, are not allowed to teach the students. The difference is that you teach the students when they experience the need. And you answer their specific questions. But you do not hand them ready-made guidelines for performing the experiments.
- When you manage to engage some students in class, this will often "infect" other students to also participate and they involve themselves in performing the tasks required to undertake experimentation.
- Students are more willing to share their findings from their experiments with others following a more open and self-directed and self-guided course, than students following a traditional course.

Keys to success

Listed here are the keys to success mentioned by the science teachers in these interviews on IBSE based teaching:

- Teaching based on the IBSE approach often requires skills and knowledge on multidisciplinary subjects. Most teachers do not possess this knowledge. This challenge can be supported by setting up fora for teachers to exchange ideas, discuss problems, ask for help, etc.
- Make sure that your focus on innovation and entrepreneurship goes hand in hand with your focus on IBSE.
- Obstructions may be one way to steer the students in the right direction, or to rethink their experiments or their findings.
- "Traditional" problem and project based learning has focused mostly on the role of the students. The 6F (or 5E) focusses on the role of the teacher. And the focus is on the teacher's role as a guide throughout the process. Hence it is important not leaving the students alone with their challenges, but setting up a scenario for the guidance to take place in each step of the model.
- If the students are not engaged, the IBSE setup will die. The Engage phase is essential.

IBSE course at the Odsherred upper secondary school

In May 2014, we held the first course specifically focused on IBSE. We invited all science teachers at one selected school to participate. The learning objectives for the course were: *"After this course you* *will ...*

1. *... have knowledge and experience in Inquiry-based Science Education*
2. *... have experience of implementing IBSE with your students*
3. *... implement a language among the participating teachers on the main pedagogical/didactic terms when working with IBSE"*

The outline for the course was as described in Table 2.

Day 3

The final day for the course will take place in September when teachers all have had a chance to meet with their classes and will have introduced the IBSE teaching approach to the classes. We will then gather the experiences and discuss experiences with the participating teachers.

Planned activities

Two more courses are planned, similar to the one above, but due to the summer vacation these will beginning early August. To accompany the courses, we are writing a compendium to support the participating teachers and to support their task as leading teachers in the future.

Who's involved at Copenhagen University

At the University of Copenhagen Jan Alexis Nielsen (Assistant professor), Lærke Bag Jacobsen (Consultant of Research Activities), Klavs Frisdahl Jacobsen (Consultant of Research Activities),

Day 1	**Time**	**Subject**		
	9:00	1) **Welcome**		
	9: 25	2) Example of IBSE in practice: **Event 1: Physics**		
	10: 10	**Pause**		
	10: 20	3) **What happened?**		
	10: 50	4) Example of IBSE in practice: **Scenario 2: Mathematics**		
	11:35	**Lunch**		
	12:10	5) **Plenary debate** -> 5e teaching model		
	12:40	6) The teachers are divided into groups to develop **material** for IBSE based courses 12:40 Groups established 13:00 The groups choose a theme and groups working 13:30 Dating (share ideas) 13:45 The groups continues working 14:30 Voluntary presentation from a group of first stage		
	15:00 to 15:30	7) Status, new groups?		
Day 2	**Time**			
	9:00	8) **Today's plan**		
	9:10	9) **Testimonials and frustration:** How did it go? What can you achieve with students? Challenges? Learning outcomes? What is good and not good? How to comply with regulations? How do we evaluate?		
	10:00	1 0-1) Groups that did not finish yesterday **continues.**	1 0-2) Groups that are ready can either create new courses or **practice** how to use the material to another group.	10-3) Groups who will not practice prepares a plan for summative **evaluation** of both skills and core competences in their course
	11:35	**Lunch**		
	12:10	**Microteaching:** The groups (2 and 2) test their progress		
	13:10	Pause		
	13:25 to 14:00	**Plenary – final evaluations and plans for August activities**		

Table 2. Outline for the course

Claus Jessen Jacobsen (Consultant), and Fie Lykke Hansen (Student helper) are all working on the PROFILES project.

References

Danske Science Gymnasier. http://science-gym.dk/

Hofstein, A., & Mamlok-Naaman, R. (2014). Case Studies on PROFILES Teacher Training (CPD) and Ownership. In C. Bolte, J. Holbrook, R. Mamlok-Naaman & F. Rauch (Eds.), *Science Teachers' Continuous Professional Development in Europe. Case Studies from the PROFILES Project* (pp. 161–164). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Hofstein, A., Katchevich, D., Mamlok-Naaman, R., Rauch, F., & Namsone, D. (2012). Teachers' Ownership: What is it and How Is it Developed? In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 57–59). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Rauch, F., & Dulle, M. (2014). Case Studies on PROFILES Networking and Dissemination. In C. Bolte, J. Holbrook, R. Mamlok-Naaman & F. Rauch (Eds.), *Science Teachers' Continuous Professional Development in Europe. Case Studies from the PROFILES Project* (pp. 245–250). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Rauch, F., & Dulle, M. (2012). How to Involve Stakeholders in IBSE Networks. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 59–67). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

PROFILES. (2010). http://www.profiles-project.eu/

Schulte, T., & Bolte, C. (2014). Case Studies on Science Education based on Stakeholders' Views Obtained by Means of a National/International PROFILES Curricular Delphi Study. In C. Bolte, J. Holbrook, R. Mamlok-Naaman & F. Rauch (Eds.), *Science Teachers' Continuous Professional Development in Europe. Case Studies from the PROFILES Project* (pp. 19–23). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Schulte, T., & Bolte, C. (2012). European Stakeholders Views on Inquiry-based Science Education – Method of and Results from the International PROFILES Curricular Delphi Study on Science Education Round 1. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 42–51). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

4.6 Inquiry-based Science Education within the Project PROFILES in Georgia

Marika Kapanadze & Ekaterine Slovinsky – Ilia State University, Georgia

Abstract

Ilia State University became a project consortium member in January 2013. All activities due to project proposal have been planned and implemented in Georgia during 2013–2014. Continuous Professional Development for the teachers, Delphi Study, Students Gains, Teachers attitudes about the implementation of IBSE – all these activities and studies have been undertaken in Georgia. The article indicates the outcomes of the PROFILES project in Georgia.

Introduction

Results of the Relevance of Science Education Study (Schreiner & Sjøberg, 2004) illustrate that students in many countries have little interest in science and in learning science. To cause a change, different reports (National Research Council, 2000; Rocard et al., 2007) suggest that Inquiry-based Science Education (IBSE) might be an innovative approach to enhance motivation and learning outcomes.

National educational reforms in Georgia began in 2004. Since 2004, several versions of a new national curriculum for both elementary and secondary schools were piloted and implemented. Much attention was paid to developments within the new science curricula, which acknowledge a more inquiry-based and student-oriented approach (Kapanadze, Janashia & Eilks, 2010; Slovinsky, 2012).

The new textbooks appeared in Georgian Schools, but teachers aren't prepared to follow the process. The schools aren't equipped accordingly and the teachers do not possess the skills to conduct the learning process according to curricula.

One consequence of the reform was a focus on the standards and syllabi pertaining to science teacher education. In Georgia, new standards for science teachers were developed and approved (Teacher's Professional Development Center, 2012). These specified the specific competencies required of the science teachers, which should allow them to effectively achieve the desired outcomes defined in the National Curriculum. 'Teachers House', which was responsible for teacher training in Georgia, organized centralized short term training.

The reform is ongoing, but the low quality of science teaching in schools and its impact on the students' motivation is often highlighted during meetings and national conferences in Georgia.

Educational projects, such as PROFILES (Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science) support the enhancement of motivation and also disseminating the IBSE approach in Europe (Bolte, Holbrook & Rauch, 2012).

Ilia State University (ISU) is one of the major universities in Georgia with pre-service and in-service teacher preparation programmes. ISU became an official member of the PROFILES science consortium in January 2013.

Continuous professional development (CPD), teacher ownership and new PROFILES modules

Two rounds of Teacher Professional Development with 40 teachers were held since January, 2013. Participant teachers were from different parts of Georgia. The duration for each CPD round was 50 contact hours. The professional development was oriented to enhancing the skills of teachers. During the workshops, creative thinking, problem solving and designing socio-scientific learning environment were supporting by the providers. Based on 3-stage model, the philosophy of PROFILES was introduced to participants of the CPD.

Teachers selected materials (teaching modules) from the project web page (PROFILES, 2010), or they designed modules by themselves. During these two rounds, six new and four already tested modules by PROFILES and PARSEL Consortium members were implemented in Georgian schools, involving 24 state and 10 private Georgian schools.

PROFILES promotes the professional development of teachers at four specific level – teacher as a learner, teacher as teacher, teacher as reflective practitioner and teacher as a leader.

As it is suggested by leaders of the WP5 (Bolte, Holbrook & Rauch, 2012; PROFILES, 2010), in order to develop a sense of ownership among teachers, it is important to develop two initial and basic components of the four component CPD model used in PROFILES, teachers as learners and teacher as teacher. These are promoted during our CPD programmes. At the 3rd stage – teacher as a reflective practitioner – a sense of ownership of PROFILES project starts to be developed in the teacher's mind. This sense of ownership is observed among the participating teachers (Hofstein & Mamlok-Naaman, 2012).

Professional development regarding stages of concern towards inquiry-based science education

The aim of the CPD training and the work with PROFILES modules is to encourage in-service teachers to implement IBSE and education through science in their schools and integrate the approach into their teaching practice (Bolte, Holbrook & Rauch, 2012; PROFILES, 2010). In order to evaluate the impact of the provided CPD programme, we analyze teachers' attitudes about their profession.

To gain insights into in-service teachers' attitudes about the implementation of IBSE and education through science, we refer to the "Stages of Concern

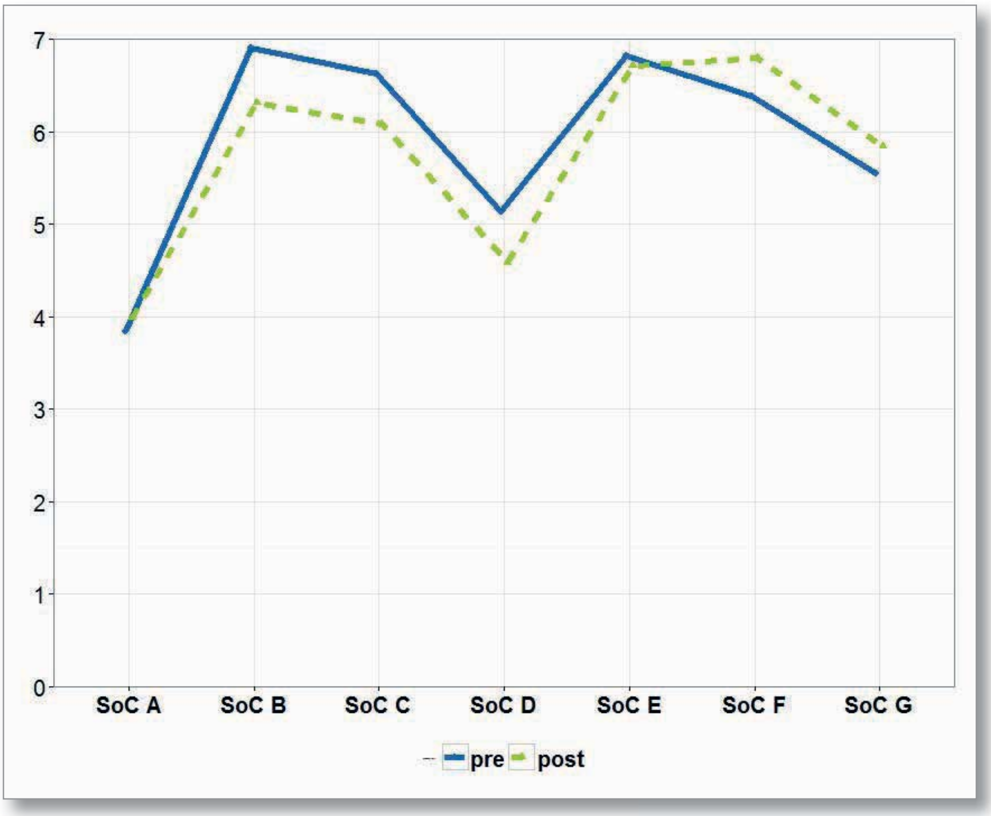


Figure 1. Stages of Concern profiles of the Georgian in-service teacher PROFILES group (N=19) in the pre- and post-tests; SoC A "Unconcerned"[1], SoC B "Informational", SoC C "Personal", SoC D "Management", SoC E "Consequence", SoC F "Collaboration" and SoC G "Refocusing" – Mean scores (Differences in SoC B and F are statistically significant – p < .05) (status: September 2013).

(SoC)" theory and questionnaire (Hall & Hord, 2011). The ISU team adapted a German SoC questionnaire, focusing on IBSE, which was developed and tested by Schneider and Bolte in accordance with Hall and Hord, (Schneider & Bolte, 2012). The Georgian questionnaire was applied as a pre- and post-test in the frame of the Georgian PROFILES continuous teacher-training programme for the both CPD rounds. Below the results of the analysis after the first round are presented. As the implementation process finished in June, 2014, the results of the second round are in progress.

19 science teachers from different regions of Georgia participated in the 1st PROFILES CPD programme (7 biology, 6 chemistry, and 6 physics teachers).

Regarding our more empirical insight, the analyzed Stages of Concern profiles for both times of collecting data (pre- and post-test) are shown in Figure 1.

We observe a 'positive' result regarding the development of the teachers' professional attitudes about the implementation of IBSE in school. At both times of collecting data, we monitored the typical SoC profile of a 'Cooperator' (Bitan-Friedlander, Dreyfus & Milgrom, 2004). With the theory of planned behaviour in mind (Ajzen, 1991), the participants of the PROFILES CPD programme in Georgia are expected to integrate IBSE related PROFILES modules into their teaching practice with high probability (Schneider, Kapanadze, Bolte & Slovinsky, 2013).

Analyses shows that the participating teacher are more informed about IBSE (SoC B) and have a stronger focus on Collaboration (SoC F) at the end of our PROFILES treatment course. Considering the SoC scale "Refocusing" (SoC G), the participants were also more concerned about optimizing IBSE at the end of the CPD course. These results can be considered positive for the implementation of innovative educational programmes (Hall & Hord, 2011).

[1] Please note: A high value on the SoC-Scale A "Unconcerned" means that the test persons' awareness about Integrated Science is on a low level.

Determining students gains (MoLE)

The goal of science education is to enhance students' scientific literacy. Students' motivation has been found to play the most important role in their conceptual change processes, critical thinking, learning and hence science learning achievement (Lee & Brophy 1996).

Instrument for analyzing Motivational Learning Environments (MoLE) in science classes (PROFILES, 2010) was translated into Georgian language. Data was collected in all PROFILES classes. About 2000 students were involved in this study.

As the PROFILES modules implementation period ended in June 2014, results are in progress and will be reported and shared among the consortium partners soon.

Curricular Delphi Study

The central aim of a Curricular Delphi Study, in the frame of PROFILES project, is to collect the opinions of stakeholders from different domains within society on the aspects of Science Education and classify them in a systematic and appropriate way (PROFILES, 2010) for guiding the professional development programmes for teachers within PROFILES.

The Curricular Delphi Study on Science Education in Georgia is structured into three rounds.

1st round

The PROFILES group in Georgia has used the same questionnaire as the FUB group in PROFILES (Bolte & Schulte, 2011). The questionnaire has been translated into Georgian language and adopted to the Georgian context, but has still remained as close as possible to the German version.

A final classification system for the analysis of the participants' statements was developed and established on the basis of the FUB system.

When comparing our results to the German results, the main differences are apparent in some categories characterizing more pure scientific fields, such as optics or biochemistry/biophysics and also in some categories of concepts and topics, characterizing more new technologies and connection between phenomena. There are some differences visible also in qualification and methodological aspects. Georgian experts give, in more detail, the categories of inquiry skills in qualification and also stressed some methodological aspects on student-based learning.

Figure 2 shows the frequencies of the categories which were mentioned by the stakeholders. In the analyses, we have focused on categories that were mentioned rarely (<5%), or particularly often (>20%). The following descriptions were structured according to the different parts of the classification system, focusing on the results regarding the whole sample, as well as regarding the different sample groups. Here we present only the results for the whole sample.

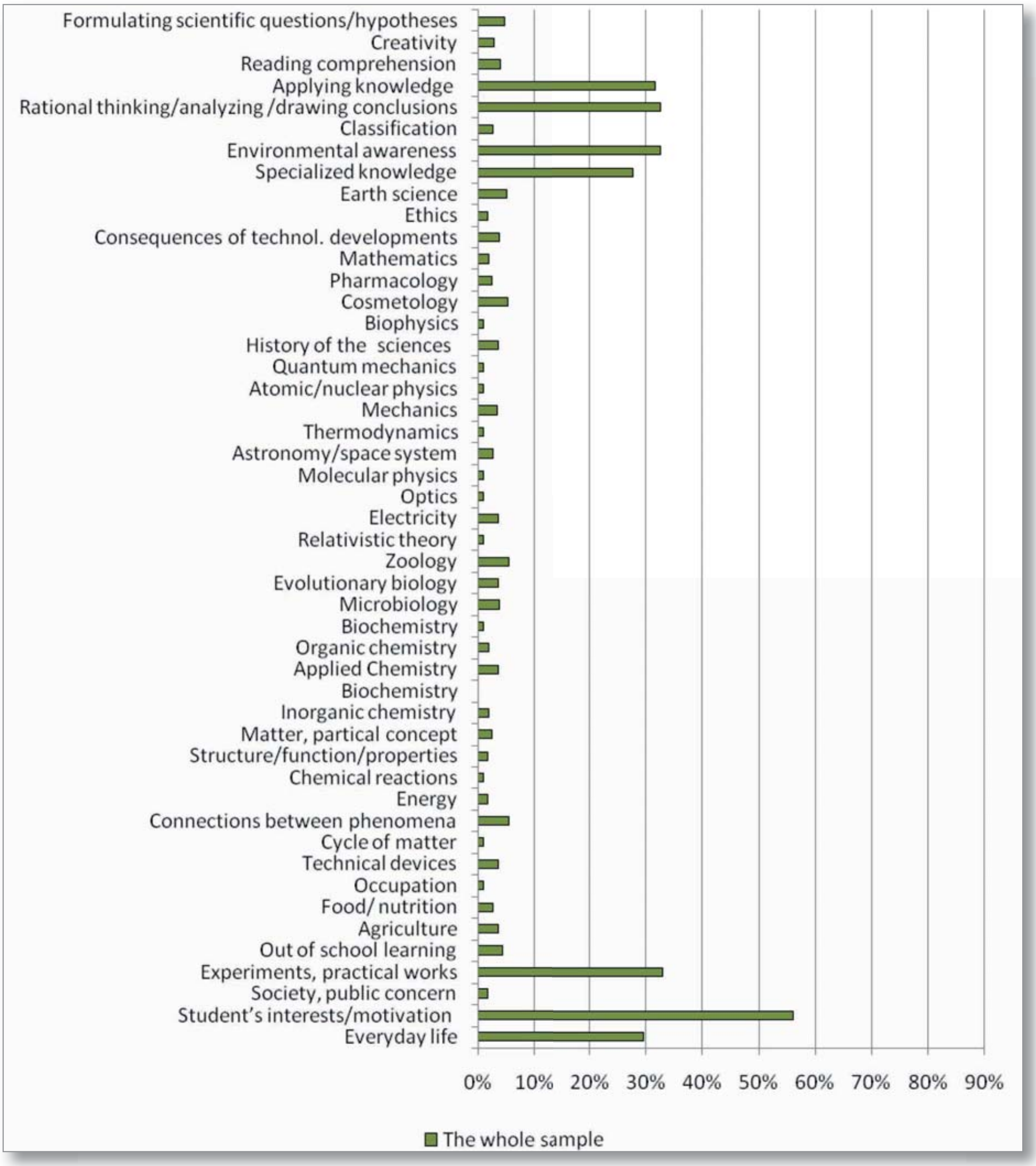


Figure 2. Overview of the categories that were mentioned rarely (<5%) or often (>20%): Mean percentages regarding the whole sample

2nd round

The second round of the Curricular Delphi Study was based on the questions which resulted from the first round analysis.

As the second round of Curricular Delphi Study consists of two parts, the results are presented in two parts also. The first part gives the descriptive and variance statistical analyses, the second part – hierarchical cluster analyses.

The results of the analysis of priority assessment shows that the top ten categories refer to the aspects related to general education and everyday life. The highest mean value, with the regard to priority in participants' responses, is the category "Acting reflectively and responsibly" and the lowest category, "Cosmetology." Most of the ten lowest categories refer to specific fields of science, such as Atomic/nuclear physics, Relativistic theory, or Pharmacology.

Analyzing these results, it is clear that, in some cases, different sample groups generally consider the same categories as relevant and important. The results of the analysis of practice assessment shows that the highest mean value is assessed as Mathematics by the total sample and the lowest mean value is the category, Occupation.

An analysis of priority-practice differences shows that the difference value is large in some cases. It is visible, that all the ten largest priority-practice differences feature values higher than 2.0, while the ten smallest priority-practice differences range between 1.1 and 0.79. These outcomes thus indicate that the priority values are larger than the practice values.

The maximal gap between priority-practice is given for the category, Inquiry–based science learning, and the smallest for inorganic chemistry. The difference for Curriculum framework is also low for Georgia, but still positive, not as is the case of FUB (Schulte & Bolte, 2012).

For identifying important concepts regarding science education, the participants were asked to combine, from the given set of 109 categories, those categories which seemed important to them in their own combinations. Based on the analyses of their responses, three concepts were formulated regarding desirable science education:

Concept A: Awareness of the sciences in social and scientific contexts, in both educational and out-of-school settings;

Concept B: Intellectual education in contexts of scientific inquiry, development of general skills and occupations;

Concept C: General science-related education and facilitation of student's interest in contexts of everyday life, using modern and various methods of education.

It is important to know that only a combination of these three concepts makes a pedagogically reasonable contribution to the desirable general and science related education.

3rd round

The aim of the 3rd round is to identify which priority and reality assessments the participants assign to the three concepts of desirable science education, derived from the hierarchical cluster analyses in the 2nd round. Also, to find out where, due to opinions of the participants, priority and realization in science education practice drift apart.

The results of the 3rd round are in progress to be announced soon.

Summary

The National PROFILES Conference was held at Ilia State University on 31st May, with about 100 participants. Teachers reported about their PROFILES practices at schools. The main conclusion made at the conference was: PROFILES offers varied teaching and learning approaches, promoting the development of diverse skills, including problem solving, team working, communication, organizational and investigative capabilities, all with a specific focus on the development of Inquiry-based Education through Science Education in the classroom.

From the teachers' feedback, it is clear that the PROFILES modules were received very well and that the PROFILES project has been implemented successfully.

The results of the DELPHI Study, MoLE and SoC will help the educational professionals and teachers in Georgia to enhance the quality of science education.

PROFILES in Georgia is on a 'good course' to assist teachers, not only those participating in PROFILES, become better professionals and implementers of IBSE.

References

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes, 50*(2), 179–211.

Bitan-Friedlander, N., Dreyfus, A., & Milgrom, Z. (2004). Types of "teachers in training": the reactions of primary school science teachers when confronted with the task of implementing an innovation. *Teaching and Teacher Education 20*(6), 607–619.

Bolte, C., & Schulte, T. (2011). PROFILES Curricular Delphi Study on Science Education. Interim Report on the First Round of the FUB Working Group. *Polyscript (Status July 2011). Unpublished*.

Bolte, C., Holbrook, J., & Rauch, F. (Eds.). (2012). *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project.* Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Hall, G. E., & Hord, S. M. (2011). *Implementing change: Patterns, principles, and potholes (3rd ed.)*. Pearson Education.

Hofstein, A., & Mamlok-Naaman., R. (2012). Teachers' Ownership: What is it and how is it Developed? In C. Bolte, J. Holbrook & F. Rauch. (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 56–58). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Kapanadze, M., Janashia, S., & Eilks, I. (2010). From science education in the soviet time, via national reform initiatives, towards an international network to support inquiry-based science education – The case of Georgia and the project SALiS. In I. Eilks & B. Ralle (Eds.), *Contemporary Science Education* (pp. 237–242). Aachen: Verlag Shaker.

Lee, O., & Brophy, J. (1996). Motivational patterns observed in sixth-grade science classrooms. *Journal of Research in Science Teaching, 33*(3), 585–610.

National Research Council. (2000). Inquiry and the National Science Education Standards. A *Guide for Teaching and Learning* (8th ed.). Washington DC: National Academy Press.

PROFILES. (2010). www.profiles-project.eu

Rocard, M., Csermely, P., Jorde, D., Lenzen, D., Walberg-Henriksson, H., & Hemmo, V. (2007). *Science Education Now: a renewed pedagogy for the future of Europe*. Brussels: European Commission.

Schneider, V., & Bolte, C. (2012). Professional Development regarding Stages of Concern towards Inquiry based Science Education. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education Europe: Reflections from the PROFILES Project* (pp. 71–74). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Schneider, V., Kapanadze. M., Bolte, C., & Slovinsky, E. (2013). Project PROFILES and Development of In-service Teachers' "Stages of Concerns" Regarding IBSE in the Context of the Implementation of PROFILES Modules in Georgia. *Proceedings of the International Conference on Physics Education, ICPE-EPEC*, pp. 1039–1043. Prague: Czech Republic.

Schreiner, C., & Sjøberg, S. (2004). ROSE: The relevance of science education. Sowing the seeds of ROSE. *Acta didactica*, 4.

Schulte, T., & Bolte, C. (2012). European Stakeholders Views on Inquiry Based Science Education – Method of and Results from the International PROFILES Curricular Delphi Study on Science Education Round. In C. Bolte, J. Holbrook & F. Rauch (Eds.), *Inquiry-based Science Education in Europe – Reflections from the PROFILES Project* (pp. 42–51). Berlin: Freie Universität Berlin

(Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Slovinsky, E. (2012). SALiS and educational policy in Georgia. *Proceedings of the Student Active learning in Science Final Conference* (pp. 101–102), Tbilisi.

Teacher's Professional Development Center. (2012). *Science teacher's standards*. Tbilisi, TPDC.

4.7 Teachers' Ownership towards Developing New PROFILES Modules

Marika Kapanadze & Ekaterine Slovinsky – Ilia State University, Georgia

Abstract

PROFILES aims at developing teacher professionalism, enhancing teacher self–efficacy and promoting teacher evidence-based ownership of PROFILES ideas and innovative practices. Two rounds of PROFILES continuous professional development were conducted in Georgia during 2013–2014. Six new and four adapted modules were implemented in Georgian Schools. New modules are discussed for development of a sense of teachers' ownership of the PROFILES approach during the workshops and implementation of the project.

Introduction

The Goal of Science education is to enhance students' scientific literacy. Students' motivation plays an important role in their conceptual change processes, critical thinking and science learning achievement in enhancing scientific literacy (Tuan, Chin & Sheh, 2005).

PROFILES, devised to give teachers self-efficacy, and for some, ownership of the PROFILES approach to the teaching of science subjects, strives to enhance the scientific literacy of students. Through a PROFILES CPD model, partners aim to develop teachers' competences in a way that they are able to work with their students in improving their specific skills such as decision-making, asking questions, problem solving, argumentation, etc. (PROFILES, 2010)

Two rounds of the PROFILES CPD programme were conducted in Georgia, in which 40 science teachers from different towns participated. During these programmes, the CPD providers worked with the teachers, amongst a variety of teacher needs, on IBSE techniques and the development of different modules in Physics, Chemistry and Biology. Georgian teachers were very motivated and worked with great interest.

PROFILES promotes the professional development of teachers in four specific components – teacher as a learner, teacher as an effective teacher, teacher as a reflective practitioner and, for some, teacher as a leader.

As suggested by the leaders of WP5 (Hofstein & Mamlok-Naaman, 2012), in order to develop a sense of ownership of the PROFILES approach among teachers, it was considered important to develop two initial and basic components of the four components of the CPD model used in PROFILES, namely teachers as learners and as teachers in the classroom. These two components were visible during the CPD programmes in Georgia. In the 3rd component – teacher as a reflective practitioner, a sense of ownership started to be developed in the teacher's mind.

For the development of teacher ownership of the PROFILES approach during the CPD courses, the model used was proposed by Loucks-Horsley, Stiles and Hewson (1996). Based on this model an image of effective classroom learning and teaching was defined, which emphasized inquiry-based learning in conducting students' investigations and the application of knowledge. During the CPD, science teachers were provided with opportunities to develop their science knowledge and teaching skills for creating better learning opportunities for the students and in supporting them to take on leadership roles, if they were inclined to do so.

During the CPD workshops, Georgian teachers became familiar with the rationale and purpose of the PROFILES project. The importance of motivation through the use of student centered strategies was emphasized. Teachers were led to understand the significance of education through science and why inquiry is put forward as an integral part of this, alongside teacher motivational techniques, context-based teaching approaches and the involvement of students in socio-scientific decision-making via the PROFILES 3-stage model. Teachers chose the relevant contexts for their students and they either used already suggested modules from PROFILES partners, or created their own within the suggested PROFILES frame.

The PROFILES approach to stimulate students' motivation for learning in science lessons is based on several issues, one of them is – teaching, initiated by means of a real scenario (PROFILES, 2010). All PROFILES modules, developed and implemented in Georgia are based on real socio-scientific issues.

New PROFILES modules

Cheese making: which to use – modern technology or nature's way?

This module is created by Natia Bagatrishvili, Biology teacher from Telavi State School N7. The story is based on a real issue following a student visit to her grandmother in a village when seeing a flask with very interesting material in it – this was the abomasums of young calves which are to be put into whey, together with some salt and vinegar, as well as beans, wheat and corn seeds. Students derived the answer that this material was for the cheese making in a natural way and they decided to investigate cheese production technology.

The main scientific inquiry question for this module – what are the factors affecting the production of cheese starting from milk?

After the students formulated different hypothesis, one group started to investigate the effect of temperature on cheese production. Another group investigated the influence of the quality of milk and the nature of enzymes.

They conducted different experiments to study the process. During the module implementation, new questions were raised such as:

(a) Why must the abomasums be dried?
(b) What will be the result if we take the abomasums, not from young calves, but from cows, sheep or pigs?
(c) Why is the abomasums put in vinegar? What is the role of beans, wheat or corn put in the liquid?
(d) If we take the pepsin, obtained in a synthetic way, what will be the results?

Picture 1 & 2. Cheese making module

Implementation – 4 lessons.

After implementation, students made conclusions and gave answers to the main question. In addition students found out the information about the history of cheese production in Georgia. They prepared an article about cheese production for the newspaper.

This module will be disseminated in Kakheti region to about 50 teachers soon.

What material keeps information for a long time?

The module is created by Irma Avaliani, Biology teacher at GLC school, Tbilisi.

The story is based on a real issue when the students who were participating in an intellectual game couldn't answer the question "What is it? It remained stable for 42 000 years in the cold Siberian tundra, answering the secret of Napoleon's death, defended suspected persons in their use of narcotics." Students made hypothesis about the content of the material, found out the information and formulated several questions about the stability of proteins.

The main scientific inquiry question for this module was put forward as – have all proteins the same stability? Students formulated their hypotheses about the stability of different proteins and started to investigate it.

Implementation – 4 lessons. Experiments were conducted with the proteins from egg, muscle and hair. Conditions for denaturation were investigated. The stability of the proteins was identified. Students read several scientific articles.

Students found out that the most stable protein is hair protein, this being called Keratin.

Picture 3. Protein stability

Innovations of this module:

- For students to put forward the question for investigation themselves
- Students are able to compare different proteins' properties during one experiment
- Students are able to conduct theoretical and experimental investigations
- Students are able to formulate new investigation questions

At the end of this module students prepared an article about proteins for the newspaper.

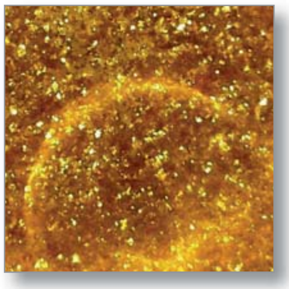
Is all that shines gold?

The module is created by Rusudan Ustiashvili, Chemistry teacher at school ''Opiza''.

The story is based on a real issue when students saw how people in mountains were extracting gold from the mountain river using an old traditional Georgian method. This raised the question in the student's mind as to whether all that shines is gold and how could they investigate this aspect.

Students searched and found information about alchemists and decided to attempt to produce gold in the laboratory.

Students conducted different experiments with KI and $(CH_3COO)_2Pb$ – one of the recipes they found from the literature. The students found they could produce a gold-like substance. But was it gold! They formulated their own hypothesis about the content of this substance and put forward reasons in support of their hypothesis. They planned different tests to find out whether this substance had the properties of gold.



Picture 4 & 5. Module „Js all that shines gold?"

Unfortunately (but without too much disappointment as the students enjoyed the investigation), after the chemical investigations they concluded that this substance wasn't gold.

Implementation – 3 lessons.

Why cans of Coca Cola sink and cans of Coca Cola Zero float

This module is created by a group of teachers, who used Freie Universität Berlin materials from the project SALiS (Streller, Hoffmann & Bolte, 2011; Streller, 2012).

The story is based on a real issue when students, during an excursion, wanted to get cold drinks by using cold water from the river. But they found out that after putting Coca Cola in a river, cans of normal Coca Cola sank in the river while cans of Coca Cola Zero floated.

Students investigated the content of both drinks, predicted the possible reason for the heavier coca cola (and predicted this is about density differences), constructed graphs and made conclusions about the sugar content of these drinks (being the cause of the change of density).

After reaching their conclusions, the students discussed about a healthy style of life and healthy drinks and prepared some recommendations.

Implementation – 4 lessons.

Why jam, confiture and salted products aren't spoiled over a long period of time?

This module is created by Marina Bagalishvili, Biology teacher at Tbilisi state school N 145.

The story is based on a real issue when the boy asked his elder brother why they only need the refrigerator for keeping some food products?

Picture 6. Storage life module

The main scientific inquiry question for this module – what is the reason that some sugared and salted products aren't spoiled for a long time?

Students formulated their hypothesis about the effect of sugar and salt on the storage of different products. Students conducted different experiments and studied the phenomena of osmosis and plasmolysis, linking these with conditions needed for the storage of foods. They investigated also the conditions for the spoiling process. Students used onion, apple and carrot for their investigations.

Implementation – 5 lessons.

All modules are developed and based on the PROFILES 3-stage model (Bolte et al., 2012):

1. Issues connected with everyday life;
2. Student-centered emphasis on scientific problem solving; (This is stage 2 of the 3-stage model)
3. Including socio-scientific decision-making to relate the science acquired to societal needs for responsible citizenship. (This is stage 3 and comes after the investigation in part 2.)

Teachers and students guides were created for all modules.

PROFILES modules enable students to gain a conceptualization of the nature of science and apply it in reflecting on the teaching undertaken in socio-scientific daily decision-making driven teaching approach where students are expected to put forward ideas, show creative thinking, develop self-determination, self-management skills and undertake self-evaluation.

Summary

Based on teacher feedback, it can be stated that PROFILES modules were successfully implemented in Georgian schools.

Teachers reported after the implementation about:

1. The enhancement of students' motivation and interest in science.
2. The students' feeling of achieving success in learning science.
3. Improvement of students' scientific, social and organizational skills.
4. Students' ability to ask questions and to

plan new experimental investigations.
5. Students' decision-making related to socio-scientific issues.
6. Students' argumentation skills in making consensus decisions.
7. Students' satisfaction with learning science.

Teachers who participated in PROFILES CPD developed, in themselves, creativity and experimental skills and gained new ideas and perspectives on science education. Many of them changed their teaching style and focused more on an inquiry-based approach. They learned a lot from each other by working together.

Based on teachers' feedback, it is clear that implementation of PROFILES modules contributed to the development of students' scientific literacy.

References

Bolte, C., Streller, S., Holbrook, J., Rannikmäe, M., Hofstein, A., Mamlok-Naaman, R., & Rauch, F. (2012). Introduction into the PROFILES Project and its Philosophy. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 31–42). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Hofstein, A., & Mamlok-Naaman, R. (2012). Teachers' Ownership: What Is it and How Is it Developed? In C. Bolte, J. Holbrook & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 56–58). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Loucks-Horsley, S., Stiles, K., & Hewson, P. (1996). Principles of Effective Professional motivation towards science learning. *International Journal of Science NISE Brief 1*(1). Madison, WI: University of Wisconsin.

Streller, S., Hoffmann, M., & Bolte, C. (2011). "Cola and Diet Cola" – a SALiS module for science lessons. FUB: Berlin. Retrieved from (in Georgian Language): http://www.idn.uni-bremen.de/chemiedidaktik/salis_zusatz/material_pdf/book_experiments_%20georgia.pdf (15.07.2014).

Streller, S. (2012). Experiencing inquiry learning. *Chemistry in Action! 97,* 18–22.

Tuan, H.-L., Chin, C.-C., & Shieh, S.-H. (2005). The development of a questionnaire to measure students' motivation towards science learning. *International Journal of Science Education, 27*(6), 634–659.

4.8 See You Later 'Navigator' – PROFILES Type Learning Environments with Special Emphasis on Occupational Orientation and the Evaluation of Their Impact on Students' Attitudes

Michael Albertus, Nina Bertels & Claus Bolte – Freie Universität Berlin, Germany

Abstract

Several studies point out that there is a lack of young people choosing careers in the sciences. Therefore, to enlighten young people about the opportunities and challenges the sciences are offering becomes more and more a major task of societies in general and of science education in particular. Our contribution focus on the conception and evaluation of a PROFILES project called "Career and Science Navigator (CSN)" (in German: "Berufe-NaWigator") created and conducted by a PROFILES working group at Freie Universität Berlin (FUB). The CSN project includes the conception of an IBSE oriented model for teaching and learning science and its empirically tested coherence as well as the development and realization of a sequence of lessons based on this model for science instruction and the evaluation of this PROFILES type learning arrangement which concentrates on connecting science education with occupational orientation in *order to analyze students' attitudes towards science, science learning and the choice of career in the sciences. By means of the PROFILES type intervention programme "Career and Science Navigator (CSN)" we are able to clarify theoretically and empirically sound how to bridge the gap between the aims of science education and the area of occupational orientation. The CSN project with its PROFILES type learning environment contributes to optimizing the support of young people in finding meaningful occupational perspectives for their lives.*

Introduction

Different reports point out that there is already a lack of young people taking jobs in the sciences in Germany and in most of the other European countries now (McKinsey, 2011; Gago, Ziman, Caro, Constantinou & Davies, 2004) and that additionally this lack will be rapidly increasing due to the demographic change for example in the German society (Brenke & Zimmermann 2005).The importance of research in the field of occupational orientation is also underlined by the International Curricular Delphi Study on Science Education (PROFILES, 2010; Schulte & Bolte, 2012). Results from this study about science education in Germany and beyond show a mismatch between desirable and actual implementation of occupational orientation in science-related learning environments (Bolte & Schulte, 2012, p. 12).

The study we present now focuses on the conception and evaluation of a project called "Career and Science Navigator (CSN)" (in German: "Berufe-NaWigator") – a PROFILES project created and conducted by a PROFILES working group at Freie Universität Berlin (FUB). This project includes the conception of an IBSE-oriented model for teaching and learning science and its empirically tested coherence as well as the realization of a sequence of lessons based on this model for science instruction and the evaluation of this PROFILES type learning arrangement which concentrates on connecting science education with occupational orientation in order to analyze students' attitudes towards science, science learning and the choice of career in the sciences in a more sophisticated manner.

Theoretical framework

In order to examine the influence of chemistry lessons or other specific PROFILES type learning arrangements to students' choice of career we combined four different theoretical approaches:

The first theoretical approach is the concept of developmental tasks formulated by Havighurst (1981). Havighurst states that people have to cope with different tasks in specific phases of their lives. The term "developmental task" was introduced by Havighurst as

> *"a task which arises at or about a certain period in the life of the individual, successful achievement of which leads to his happiness and to success with later tasks, while failure leads to unhappiness in the individual, disapproval in the society, and difficulty with later tasks"* (Havighurst 1981, 2).

Schenk (2005) defined six developmental tasks which should be dealt with in chemistry lessons (value, concepts, vocation, self, gender and body).

An additional factor – and hence our second theoretical basis – which influences the career choice related to science in general or chemistry in particular is the "self-to-prototype matching". Hannover and Kessels (2004) investigated this field in Germany. According to them, a prototype is the stereotypical image one has about typical representatives of specific groups. Whenever we choose a job, a university course or even a hobby, we compare our self-image with that of the prototype. Hence, if the students' prototype of people who work in chemical industry for example is rather negative then students are likely not to choose careers in science and technology. The picture of the 'mad scientist' comes to people's mind.

The next – and our third – approach which explains how important decisions such as the choice of future profession are psychologically influenced is the "self-concept theory" (e.g. Marsh & Yeung, 1997, Köller et al., 2000, Taskinen, 2010). Especially the work of Taskinen (2010) shows that self-concept correlates with the likeliness of taking up a scientific career.

A further and the fourth theory we adapted is the "Motivational Learning Environment (MoLE)"model that has been investigated by Bolte for more than 20 years now (Bolte, 1995; 2006). He found different dimensions which can be used to analyse the motivational learning environment. One of these dimensions is the relevance of the topics the students are dealing with in their science or chemistry lessons. From the students' point of view, their science or chemistry lessons seem to include too many topics which are not relevant for students (Bolte, 1994; 2004; Bolte, Keinonen, Mühlenhoff & Sormunen, 2013).

Taking these four theoretical concepts into consideration Bertels and Bolte found the following dependencies (see Figure 1):

- a positive science-related self-concept increases the likelihood of choosing a science-related career,
- a great gap between self-image and prototype in the scale "attractiveness"makes the choice of a science-related career less likely,
- a great mismatch between the individual weighting (priority) of the developmental task scale "self" and how the scale is perceived by the students as being present in science classes (practice) also influences the students' career choice, and finally
- one of the eight MoLE scales influences the career choice positively in a significant manner; this is the MoLE scale: "satisfaction".

Question of Interest: Based on this theoretically sound and empirically tested model by Bertels and Bolte (see Figure 1) we are interested in investigating the following question:

How can science education support students in the process of getting occupationally orientated in a proper manner in order to develop informed and reasonable attitudes regarding vocational opportunities in the fields of the sciences?

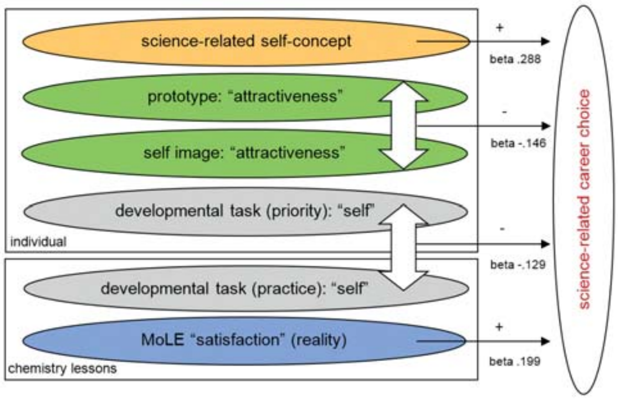


Figure 1. Results of our regression analysis – Effects of the empirically selected variables on students' science-related career choice –R^2 = .234 (+ = positive influence; - = negative influence)

Method

The Career and Science Navigator (CSN) project – a PROFILES type intervention

In the course of the PROFILES type intervention "Career and Science Navigator (CSN)", which lasts five days in total (approximately 30 hours of lessons), school classes take part in a specific learning arrangement in the Division of Chemistry Education of FUB. In the frame of this treatment the students learn about different occupations that require formal training such as laboratory chemist, chemical worker, pharmacists, specialist for sewage technology and specialist for food technology. During this project the students practice typical operations of these occupations which are also closely linked to chemical school experiments and to the science curricula like acid-base titration, burning sulfur, making an ointment, cleaning sewage and producing soy milk.

Evaluation of the CSN project's Impact on "Students Gains"

The evaluation of the CSN project is based on the career choice model by Bertels and Bolte (2010) which is described above (see Figure 1). That is why the questionnaires used to operationalize the above cited model are adapted (Albertus, Bolte & Bertels, 2011) to analyze the CSN project. Beside these questionnaires two scales from the PISA Study of 2006 were supplemented. The applied questionnaires are used in a pre-post-test design.

Research question

Based on this theoretically sound and empirically tested model by Bertels and Bolte (see Figure 1) we focus on the following question: How do different aspects (variables) related to the process of occupational orientation change from the beginning of the CSN intervention to its end?

Findings

The total sample of our treatment group consists of 95 students at the age of 13 or 14 from five different German middle school classes. During the Career and Science Navigator learning arrangement the assessments of the empirically selected characteristics developed as shown in the tables 1 and 2. The values of the career choice intentions scale and the two scales adapted from the PISA study increased over the course of the intervention. At the same time the values for the support the students experienced in dealing with the developmental tasks vocation, self and concepts during the CSN intervention show a closer match to the students' indicated priority assessments. Especially large is the difference between the values for support the students experienced in dealing with the developmental task vocation during the regular chemistry classes and during the CSN intervention.

Conclusion and prospects

By means of the PROFILES type intervention programme "Career and Science Navigator (CSN)" developed and evaluated by a PROFILES FUB working group we are able to clarify and to show how to bridge the gap between the aims of science and chemistry education and the area of occupational orientation. The CSN project with its PROFILES type learning environment contributes

Career choice Intentions – Scale[a)] (Kessels & Hannover 2006)/ PISA Scales[b)] (OECD 2009)	Before Intervention (pre-data)		After Intervention (post-data)	
	Mean	SD	Mean	SD
Wish to take a Science Career [a)]	2,1	,7	2,4	,7
Interest in Science [b)]	2,7	,8	2,8	,8
Information about Science Careers [b)]	2,2	,5	2,8	,6

(1 disagree; 2 rather not agree; 3 rather agree; 4 fully agree)

Table 1. Evaluation of the learning arrangement "Career and Science Navigator"

Developmental Task (Bertels&Bolte 2009) *(3 items each)*	Priority (students' wish to be supported in this task)		Chemistry lessons (students' perceived support during regular chemistry lessons)		CSN Intervention (students' perceived support during intervention)	
	Mean	SD	Mean	SD	Mean	SD
Vocation	3,2	,5	2,1	,8	3,4	,5
Self	3,2	,6	2,4	,7	2,6	,8
Concepts	2,5	,6	3,1	,8	2,8	,7

(1 not at all; 2,5 neutral assessment; 4 very much)

Table 2. Evaluation of the learning arrangement Career and Science Navigator– Developmental Task Scales

to optimizing the support of young people in finding meaningful occupational perspectives for their lives. This is a significant contribution with respect to the PROFILES overall aim of "students' education through science" (Bolte et al., 2012). Although the CSN project is currently a formal out-of-school learning environment (Coll, Gilbert, Pilot & Streller, 2013), we are convinced that the CSN conception can be easily transferred into school practice. Hence, our next steps will be to offer PROFILES type long term Continuous Professional Development courses for science teachers. We are optimistic that our CPD courses will enhance the participating teachers' ownership to implement the CSN conception into general chemistry lessons in school. Beside this and in the long run there is also the opportunity to adapt the CSN conception for other science subjects such as biology and physics, to implement these PROFILES type modules in schools and to professionally reflect on their impact on the students' gains.

References

Albertus, M., Bolte, C., & Bertels N. (2011). Chemieunterricht und naturwissenschaftsbezogene Berufswahlentscheidung. Höttecke, D. (Ed.), *Naturwissenschaftliche Bildung als Beitrag zur Gestaltung partizipativer Demokratie* (Vol. 31) (pp. 569–571). Münster, LIT Verlag.

Bertels, N., & Bolte, C. (2009, April). Developmental Task, Stereotypes and Motivational Learning Environments in Science Lessons (in Germany). *Proceedings of the Annual Meeting of the National Association for the Research on Science Education (NARST)*, Los Angeles, USA.

Bertels, N., & Bolte, C. (2010, March). Occupational Orientation – A Foreign Concept to Chemistry Lessons. *Proceedings of the Annual Meeting of the National Association for the Research on Science Education (NARST)*, Philadelphia, USA.

Bolte, C., Streller, S., Holbrook, J., Rannikmäe, M., Hofstein, A., Mamlok Naaman, R., & Rauch F. (2012). Introduction into the PROFILES Project and its Philosophy. C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe. Reflections from the PROFILES Project* (pp. 31–42). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Bolte, C. (1995). Conception and Application of a Learning Climate Questionnaire based on Motivational Interest Concepts for Chemistry Instruction at German Schools. In D.L. Fisher (Ed.), *The Study of Learning Environments Vol.8* (pp. 182–192). Curtin University: Perth, Australia.

Bolte, C. (2006, April). As Good as It Gets: The MoLE-Instrument for the Evaluation of Science Instruction. *Proceedings of the Annual Meeting of the National Association for the Research on Science Education (NARST),* San Francisco, USA.

Bolte, C., & Streller, S. (2011). Evaluating Student Gains in the PROFILES Project. Proceedings of the European Science Educational Research Association (ESERA), Lyon, France. Retrieved from: http://www.esera.org/media/ebook/strand5/ebook-esera2011_BOLTE_1-05.pdf (31.05.2012)

Bolte, C., & Schulte, T. (2012). Deliverable D3.2. PROFILES – Report to Stakeholders concerning 'WP3: Stakeholder Involvement' and Stakeholders Views regarding a Contemporary Inquiry Based Science Education (Unpublished Report).

Bolte, C., Keinonen, J., Mühlenhoff, T., & Sormunen, K. (2013). PROFILES Unterricht im Urteil von Schülern aus Finnland und Deutschland. In S. Bernholt (Ed.), *Inquiry-based learning – Forschendes Lernen. Zur Didaktik der Physik und Chemie. Probleme und Perspektiven* (pp. 200–202). Retrieved from: http://www.gdcp.de/index.php/tagungsbaende/tagungsband-uebersicht/145-tagungsbaende/2013/4220-band33. (15.04.2014).

Brenke, K., & Zimmermann, K. F. (2005). *Demographischer Wandel erfordert Bildungsreformen und lebenslanges Lernen* (pp. 329–335). In Wochenbericht des DIW Berlin. 19/2005.

Coll, R.K., Gilbert, J.K., Pilot, A., & Streller, S. (2013). How to benefit from the informal and interdisciplinary dimension of chemistry in teaching. In I. Eilks & A. Hofstein (Eds.), *Teaching chemistry – a studybook* (pp. 241–268). Rotterdam, Sense Publishers.

Dickhäuser, O., Schöne, C., Spinath, B., & Stiensmeier-Pelster, J. (2002). Die Skalen zum akademischen Selbstkonzept. *Zeitschrift für Differentielle und Diagnostische Psychologie, 23*(4), 393–405.

Gago, J. M., Ziman, J., Caro, P., Constantinou, C., & Davies, G. (2004). Europe needs more scientists. In *Brussels: European Community Conference Increasing Human Resources for Science and Technology*.

Havighurst, R. J. (1981). *Developmental Tasks and Education (3rd ed.)*. New York and London: Longman.

Hannover, B., & Kessels, U. (2004). Self-to-prototype matching as a strategy for making academic choices. Why high school students do not like math and science. *Learning and instruction, 14*(1), 51–67.

Kessels, U., & Hannover, B. (2006). Zum Einfluss des Image von mathematisch-naturwissenschaftlichen Schulfächern auf die schulische Interessenentwicklung. In M. Prenzel & L. Allolio-Näcke (Eds.), *Untersuchungen zur Bildungsqualität von Schule* (pp. 350–369). Münster: Waxmann.

Marsh, H. W., & Yeung, A. S. (1997). Coursework Selection: Relations to Academic Self-concept and Achievement. *American Educational Research Journal, 34*, 691–720.

McKinsey Deutschland. (2011). *Wettbewerbsfaktor Fachkräfte – Strategien für Deutschlands Unternehmen.* Berlin: McKinsey & Company, Inc.

OECD. (2009). PISA 2006. Technical Report. Paris: OECD.

PROFILES. (2010). www.profiles-project.eu

Schenk, B. (2005). Entwicklungsaufgaben und Schule. In B. Schenk (Ed.), *Bausteine einer Bildungsgangtheorie* (pp. 275–289). Wiesbaden: Verlag für Sozialwissenschaften.

Schulte, T., & Bolte, C. (2012). European Stakeholders Views on Inquiry Based Science Education – Method of and Results from the International PROFILES Curricular Delphi Study on Science Education Round 1. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 42–51). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Taskinen, P. H. (2010). *Naturwissenschaften als zukünftiges Berufsfeld für Schülerinnen und Schüler mit hoher naturwissenschaftlicher und mathematischer Kompetenz: eine Untersuchung von Bedingungen für Berufserwartungen*. Dissertation. Christian-Albrechts-Universität zu Kiel.

4.9 Aspects of Science Education from a European Perspective – First Results from a Meta-analysis of the International PROFILES Curricular Delphi Study on Science Education

Marlies Gauckler, Theresa Schulte & Claus Bolte – Freie Universität Berlin, Germany

Abstract

In the context of the PROFILES project, the "International PROFILES Delphi Study on Science Education" was conducted in 19 countries, gathering data from more than 2 700 people involved in science education or science (stakeholders). As the data of each national Curricular Delphi Study was analysed by local working groups, the results are not directly comparable. However, a comparison was attempted for the first and second round of the PROFILES Curricular Delphi study. The results of this PROFILES Delphi Studies' meta-analysis are presented in the following. First, aspects that are perceived as relevant for science education by stakeholders from different countries are collected and compared. Then, it is shown what importance is attributed to these aspects of science education, and to what extent they are considered present in current science education. From these analyses, aspects can be identified that are considered especially important but realized to a (too) low extent, providing hints about areas in current science education practice throughout Europe which might require further improvements.

Introduction

It can be argued that an

> *"understanding of science and technology is central to a young person's preparedness for life in modern society"* (OECD, 2010, p. 137).

According to a public opinion analysis in 2005, over 80% of Europeans agree that

> *"young people's interest in science is essential to our future prosperity"* (European Comission, 2007, p. 6).

In contrast, only 15% of Europeans are satisfied with the quality of science education in school (European Comission, 2007, p. 8). It seems that a vast majority of Europeans consider science education for young people highly important, but criticize the science education provided by schools as unsatisfactory. Therefore, the question arises how science education could be changed to better fulfil its important role in helping young people find their place as citizens of tomorrow's society and secure the future of European innovations and research. This question can be posed as follows: *What kinds of knowledge, abilities and attitudes related to science and science education are considered necessary and useful for young people in Europe?*

Answers to such a complex question about educational contents and goals can be collected with the Delphi method. This method is specifically useful for

> *"structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem"* (Linstone & Turoff, 1975, p. 3).

What is more, it has previously proven suitable for this task when Häußler, Frey, Hoffmann, Rost and Spada (1980) investigated aspects of physics education that can be considered relevant for the present and the future. In a similar study, the "Curricular Delphi Study in Chemistry" (Bolte, 2003a; 2008), the Delphi method was used again to collect aspects of useful and pedagogically desirable chemistry education and analyse the degree of consensus about these aspects within society. However, these studies were only conducted on a national level. The PROFILES project provides the opportunity to bring together a particularly large number of stakeholders involved in science education or science from different countries in Europe and beyond.

The international PROFILES Curricular Delphi Study on Science Education

The International PROFILES Curricular Delphi Study on Science Education was carried out in the context of the PROFILES project in order to

> *"engage in all PROFILES partners' countries different stakeholders from science or science education related areas in reflecting on contents and aims of science education as well as in outlining aspects and approaches of modern science education"* (Schulte & Bolte, 2012, p. 43).

Following the design of previous Curricular Delphi Studies (Häußler et al., 1980; Bolte, 2003; 2008), the study consists of three interrelated rounds in which the participating experts first contribute their ideas and then assess the compiled outcomes of each round (Bolte et al., 2012, pp. 36–37).

In the first round, stakeholders' answers concerning aspects of science education that are advisable and pedagogically desirable for the individual in the society today and in the near future are collected by the local PROFILES partner institutions and grouped into categories. In the second round, the resulting list of categories is fed back to the participants, which allows them to reconsider their opinion in the light of the answers from the whole group. They are asked to assess the importance of the presented aspects ("priority"), as well as the extent to which they are already present in science education today ("practice") on scales of 1 to 6. The differences between priority and practice help identify areas that are under- and overrepresented in current science education. In addition, the participants in the second round are asked to combine categories in ways that seem relevant to them. From these combinations, meaningful concepts of science education can be identified empirically through hierarchical cluster analyses. In the third round, which is the last round of the PROFILES Delphi Studies, the identified clusters are again assessed in terms of priority and practice by the participating stakeholders.

The International PROFILES Curricular Delphi Study on Science Education was planned to be conducted simultaneously as national curricular Delphi studies of the same design by different PROFILES partner institutes. For this reason,

> *“the national outcomes can not only be analysed individually, but allow also comparisons between the outcomes in different countries.”* (Schulte et al., 2014, p. 186).

Such comparisons allow a look beyond national perspectives in order to identify – on an empirical basis – opinions and attitudes towards science education on a European level. However, due to differences in the contents and degree of differentiation of classification systems created during the first round of the respective national Curricular Delphi Study, certain steps have to be taken before the results can be compared.

Method

The analysis of the classification systems that were derived from stakeholders’ statements during the first round of the national Curricular Delphi Studies follows the procedure suggested by Bolte (2003; 2008). However, for the following meta-analysis the procedure has to be modified in order to account for the fact that the source materials are not stakeholders’ statements, but already developed categories in classification systems. First, classification systems of the national PROFILES partners are examined in order to determine which one proves most suitable for comparisons. For the meta-analysis of the PROFILES Curricular Delphi Studies, the classification system developed by the FUB working group was selected, as its number of categories corresponds to the mean number of categories in all classification systems (M=88), which indicates an average degree of differentiation. In addition, the FUB classification system was adopted or used as a basis for analysis by several PROFILES partners, indicating they considered it suitable to represent their stakeholders’ statements as well. The suitability of the FUB system for the following comparisons is also reflected in the considerable overlap between categories, as we will illustrate below. Categories developed from stakeholders’ statements by national PROFILES working groups are matched with FUB categories and it is noted in how many classification systems each FUB category is included. Categories that cannot be matched to any existing FUB category will be discussed separately.

In order to analyse results of the PROFILES partners’ second rounds of the Delphi Studies, the priority and practice values provided by stakeholders from the different countries have to be compared. If values are collected for categories that differ from the FUB categories, they are matched similarly to the procedure before; in some cases, certain values have to be assigned to several categories, whereas in other cases, several values are added to one category and a mean value is calculated. This process is necessary to represent stakeholders’ opinions as accurately as possible while accounting for the variety in content and degree of differentiation.

According to the theoretical considerations and the chosen method, the following questions can be addressed:

1. Is there a consensus between stakeholders from different countries about aspects that can be considered relevant for science education?
2. How important are the empirically identified aspects of science education in the opinion of stakeholders from different countries?
3. To what extent are the different aspects of science education realized in practice in the opinion of stakeholders regarding their respective countries?
4. What differences between importance and extent of realization can be found for aspects of science education in the opinion of stakeholders from different countries?

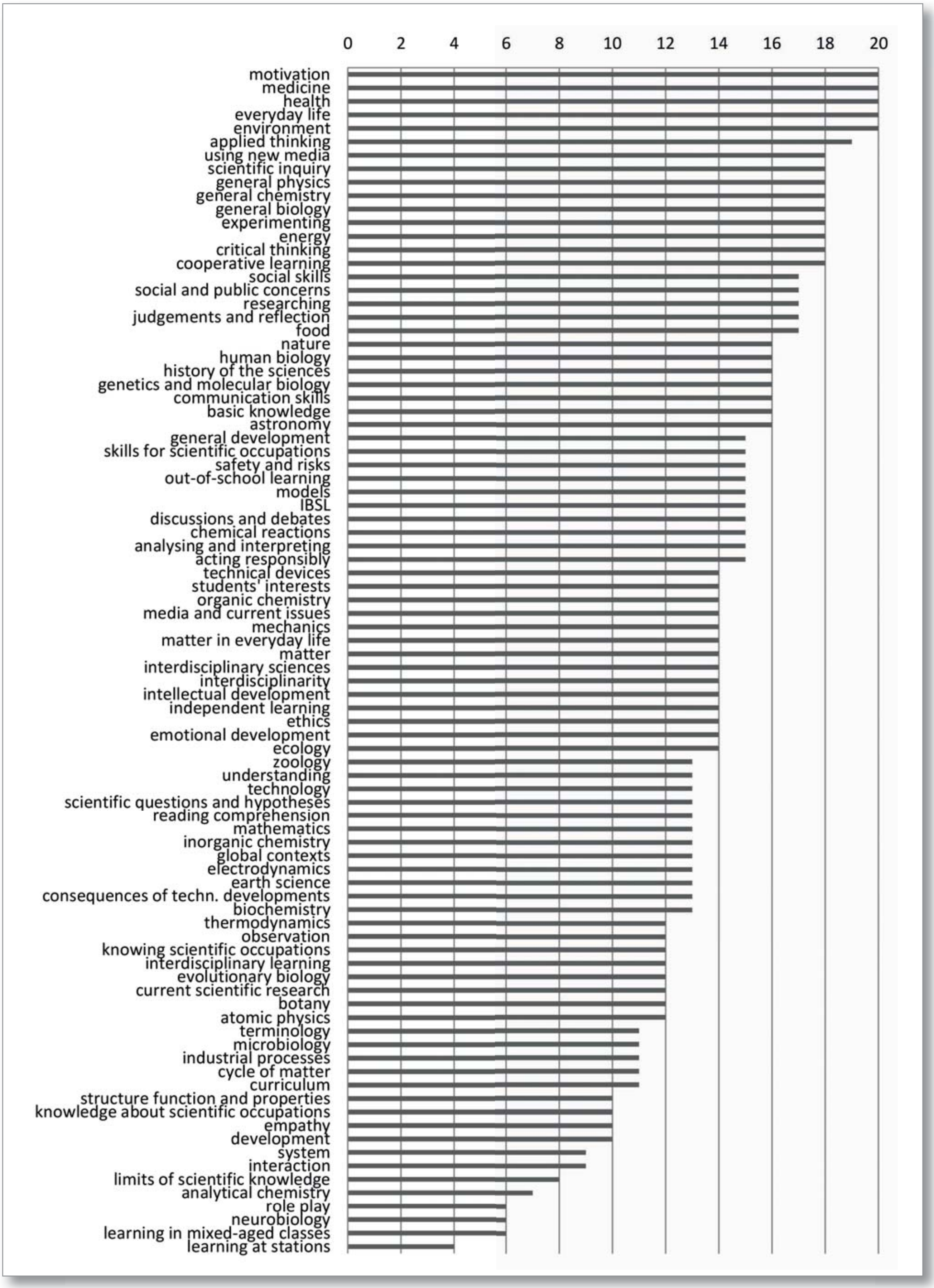


Figure 1. Frequency of FUB categories included in the PROFILES partners' classification systems (N=20)

Results

The sample for the meta-analysis consisted of 20 partners' Delphi studies with a total of 2 706 participants for the first round and 18 partners with a total of 1 867 participants for the second round.[1] This high number of participants can be considered a solid basis for first insights into what could be considered a European perspective on desirable science education. Participating countries which are not members of the European Union (Switzerland, Israel, Turkey and Georgia) are still in various respects associated with the EU and will therefore be considered in terms of a European perspective as well.

Classification systems developed by the partners from their stakeholders' statements in the first round include a number of categories between 27 (UPORTO Portugal) and 167 (UCC Ireland). However, despite these differences in the number of categories and the variety in content, it was possible to identify similarities and display them based on the FUB classification system.

Figure 1 shows how many times each FUB category is included in partners' classification systems. It was found that more than half of the categories (51 of 88) are included in the classification systems of at least 13 of 20 partners. Five categories are included by every partner: "motivation", "medicine", "health", "everyday life" and "environment". Amongst the categories least frequently mentioned are specific methods such as "learning at stations" and scientific sub-disciplines such as "neurobiology".

A limited number of categories that appear in more than one partner's classification system could not be matched with an existing FUB category. These categories were labelled as "games and competitions", "classroom equipment", "meeting with experts", "audiovisual material", "project-based learning", "determination and patience", "concept maps" and "variety of methods". While these can be considered relevant and valuable additions to the FUB categories, they are not included in the following descriptive statistical analyses because overall not enough data was collected concerning their importance and extent of realization.

For the second round, it was found that all stakeholders on average considered all categories except learning in mixed-aged classes as at least fairly important, with priority values of over 3.5, which is the theoretical mean of the used 6-point rating scale. This supports the content validity of the developed categories (Bolte, 2003b). The categories with the ten highest and ten lowest priority values are displayed in Figure 2. Error bars mark the standard deviation, which indicates the degree of agreement between stakeholders from different countries about the priority of each category.

Categories that are considered of high to very high priority (values over 5) are "basic knowledge", "analysing and interpreting", "applied thinking", "critical thinking", "motivation" as well as "judgement and reflection".

In contrast to the most important categories, only 30 out of 88 categories were considered at least fairly realized in science education with mean values over 3.5. No category reaches a value over 5, which would indicate a high to very high extent of realization. The ten categories that have been considered most and least present in science education are displayed in Figure 3. According to the stakeholders involved in this study, current science education in Europe consists mainly of curriculum orientation and scientific contents and concepts of scientific sub-disciplines. None of the ten most important categories (see Figure 2) can be found amongst the ten categories that are most present in science education. This fact can be seen as a first hint that important aspects of science education are underrepresented in practice.

From the stakeholders' priority and practice assessments, the difference was calculated. For the majority of categories, this difference was positive, indicating that this aspect is more

[1] Two partners (UU Netherlands and UMCS Poland) have not participated in the second round so far, which results in a lower number of participants. In addition, a total of 665 participants from different countries dropped out between the first and the second round of the PROFILES Delphi Studies.

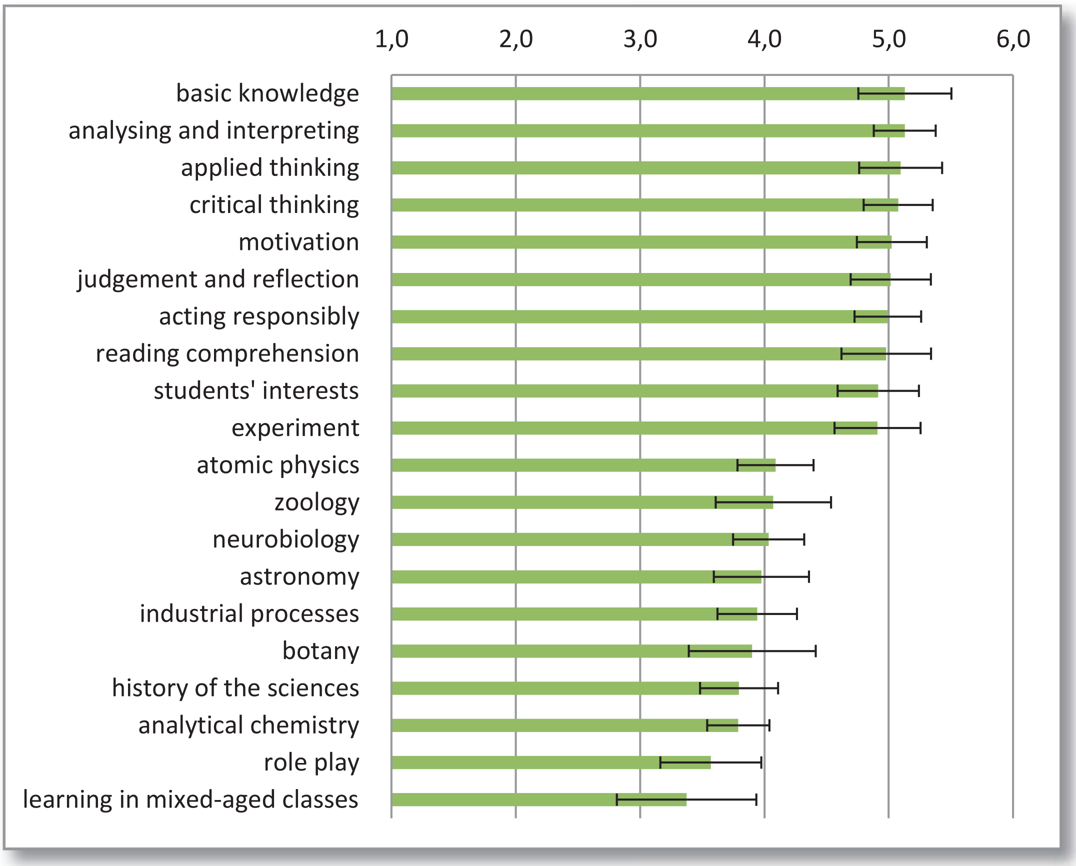


Figure 2. Categories with the highest and lowest priorities assessments (Top 10/Low 10)

important than it is present in practice and therefore underrepresented in regular science lessons. Only in some cases, in particular for categories such as "curriculum", "terminology" as well as contents and concepts of scientific sub-disciplines, negative values emerged, suggesting that these aspects are overrepresented. The ten greatest and smallest priority-practice differences are displayed in Figure 4.[2] A long bar represents a strong underrepresentation, whereas smaller bars show a closer match between importance ("priority") and realization ("practice"). The greatest priority-practice differences can be found for "applied thinking", "critical thinking", "judgement and reflection", "acting responsibly", "current scientific research", "analysing and interpreting" and "motivation". Except for the category "current scientific research", all of these categories can also be found amongst the ten most important categories. In conclusion, categories which describe general skills and competencies related to scientific thinking and reasoning, as well as students' motivation, can be considered the most important issues but at the same time the aspects that are most deficient in current science education.

Conclusion and outlook

In the context of the "International PROFILES Curricular Delphi Study on Science Education", issues and aspects of science education that can be considered meaningful and pedagogically desirable for the individual in the society today and in the near future were collected in different countries. Through a systematic analysis of the categories in the PROFILES partners' classification systems developed based on their stakeholders' statements in the first round and the priority and practice assessments of these categories in the second round of the national Delphi Studies, it was

[2] It should be noted that no negative values are found here as absolute differences were used in order to avoid positive and negative differences cancelling each other out, thereby implying stakeholders on the whole are satisfied where actually some consider it overrepresented and others underrepresented.

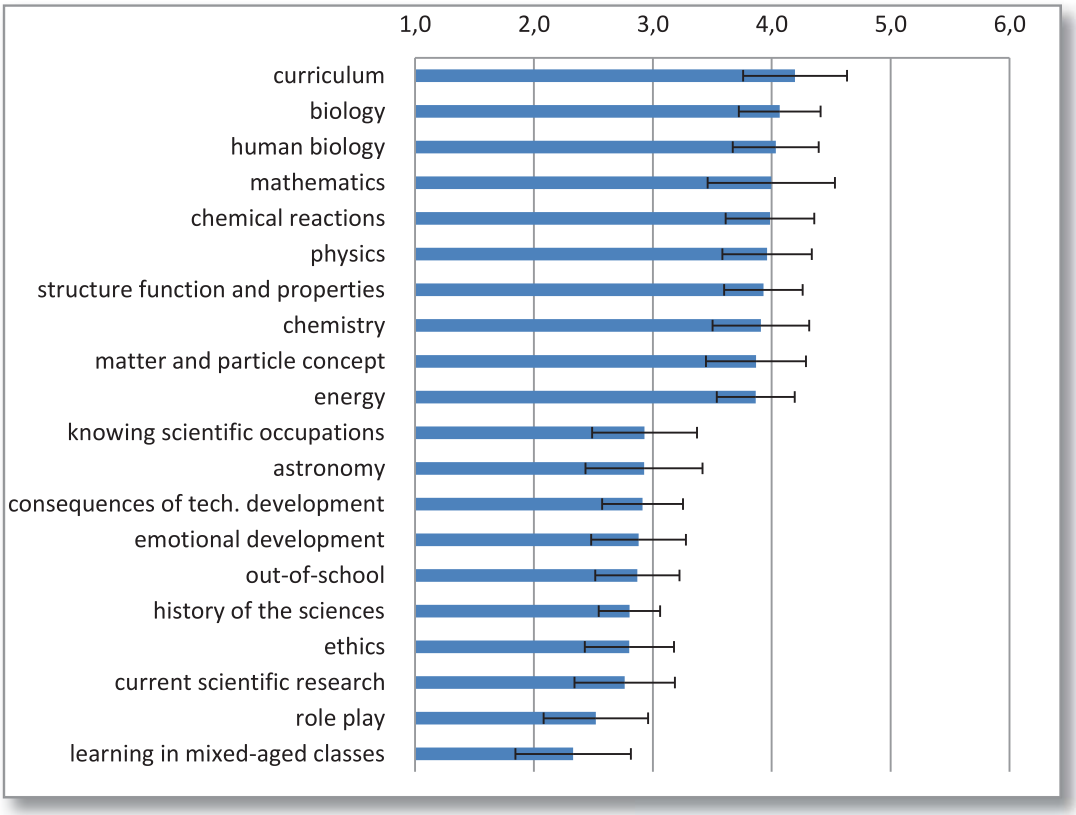


Figure 3. Categories with the highest and lowest practice assessments (Top 10/Low 10)

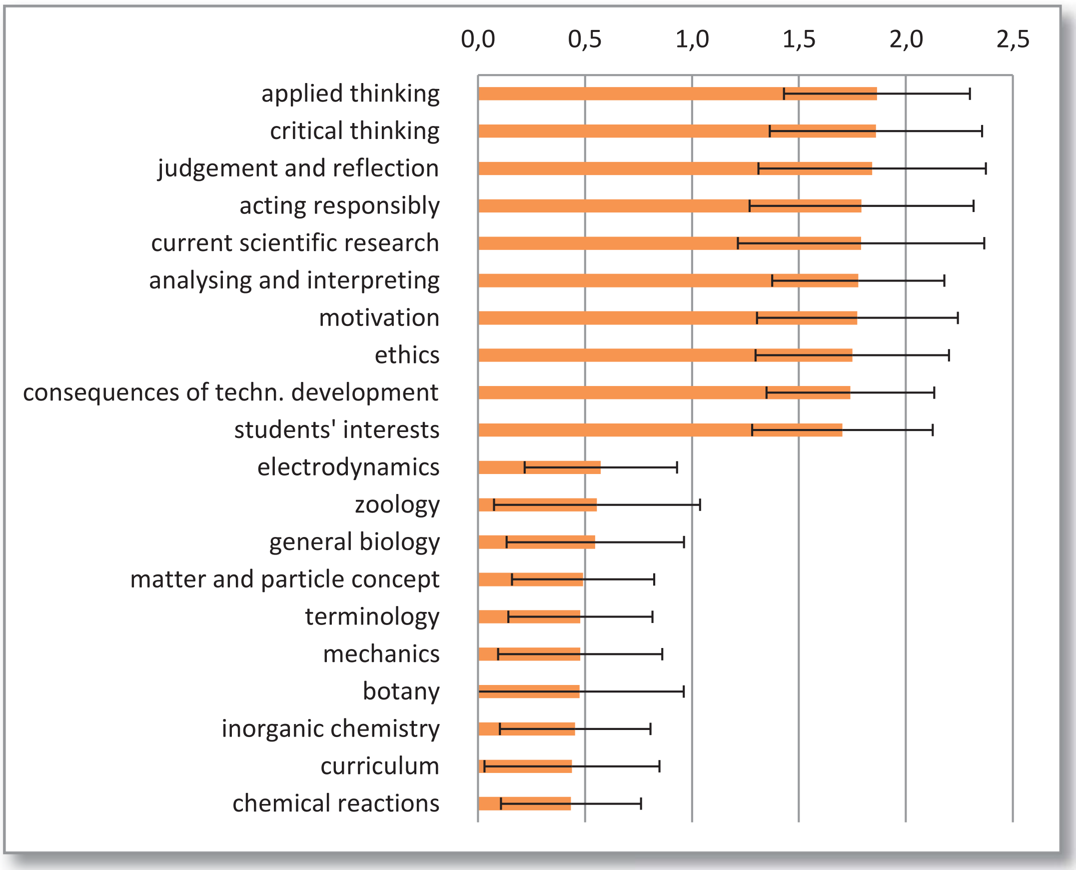


Figure 4. Categories with the greatest and smallest absolute priority-practice differences (Top 10/Low 10)

possible to provide first empirically based insights into "a European perspective on current science education".

A certain consensus between stakeholders from the participating countries about the aspects that are relevant for science education could be identified. According to the priority assessments, the most important aspects and issues of science education from a European perspective are more general skills and competencies related to scientific thinking and reasoning, such as analysing and interpreting data and observations as well as applied and critical thinking. What is more, the high priority value of basic scientific knowledge could imply that these general skills and competencies should and have to be based on and considered in interaction with basic scientific knowledge. In contrast to that, aspects that are most present in European science education seem to be specific scientific contents and concepts of specific sub-disciplines as prescribed by the national curricula in the partners' countries. This misrepresentation is further illustrated when considering the priority-practice differences. While scientific concepts in sub-disciplines show a relatively close match between importance and extent of realization, general skills and competencies related to scientific thinking and reasoning as well as students' motivation are strongly underrepresented in science education practice in Europe. This finding can be related to what is defined by the European Commission (2007, p. 6) as one of the main goals of science education – to equip every young person with the skills necessary to live and work in tomorrow's society,

> *"which rely heavily on technological and scientific advances of increasing complexity".*

In addition, similar aspects and goals of science education, which were empirically identified in this meta-analysis, are also addressed in the PROFILES project philosophy which the PROFILES consortium calls "education through science" (Bolte et al., 2012). Following the education through science concept, teachers can guide their students to appreciate the

> *"relevance of learning through 'science' for lifelong learning, responsible citizenry and for preparing for meaningful careers"* (Bolte et al., 2012, p. 35).

The empirically identified aspects and issues which were considered most important for science education might provide starting points to reach these goals in order to enhance students' scientific literacy.

Further analyses of the compiled data promise more detailed insights into the importance of the different aspects and the current situation of science education in Europe. In addition, an analysis of the third round findings of the International PROFILES Delphi Study on Science Education, in which clusters representing meaningful combinations of categories are assessed in terms of priority and practice, could provide a more condensed picture of the European perspective on a desirable and meaningful science education for today and the near future.

References

Bolte, C. (2003a). Konturen wünschenswerter chemiebezogener Bildung im Meinungsbild einer ausgewählten Öffentlichkeit – Methode und Konzeption der curricularen Delphi-Studie Chemie sowie Ergebnisse aus dem ersten Untersuchungsabschnitt. *ZfDN, 9*, 7–26.

Bolte, C. (2003b). Chemiebezogene Bildung zwischen Wunsch und Wirklichkeit – Ausgewählte Ergebnisse aus dem zweiten Untersuchungsabschnitt der curricularen Delphi-Studie Chemie. *ZfDN, 9*, 27–42.

Bolte, C. (2008). A Conceptual Framework for the Enhancement of Popularity and Relevance of Science Education for Scientific Literacy, based on Stakeholders' views by Means of a Curricular Delphi Study in Chemistry. *Science Education International, 19*(3), 331–350.

Bolte, C., Streller, S., Holbrook, J., Rannikmäe, M., Hofstein, A., Mamlok-Naaman, R., & Rauch, F. (2012). Introduction into the PROFILES Project and its Philosophy. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education* *in Europe: Reflections from the PROFILES Project* (pp. 31–42). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

European Commission. (2007). *Science Education Now: A Renewed Pedagogy for the Future of Europe.* Retrieved from: http://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf (26.04.2014).

Häußler, P., Frey, K., Hoffmann, L., Rost, J., & Spada, H. (1980). *Physikalische Bildung: Eine curriculare Delphi-Studie. Teil I: Verfahren und Ergebnisse. IPN-Arbeitsbericht 41*. Institut für die Pädagogik der Naturwissenschaften Kiel.

Linstone, H. A., & Turoff, M. (Eds.). (1975). *The Delphi Method: Techniques and Applications.* Digital version, 2002. Retrieved from: http://is.njit.edu/pubs/delphibook/ (26.04.2014).

Schulte, T., & Bolte C. (2012). European Stakeholders Views on Inquiry Based Science Education – Method of and Results from the International PROFILES Curricular Delphi Study on Science Education Round 1. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 42–51). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Schulte, T., Bolte, C., Keinonen, T., Gorghiu, G., Kapanadze, M., & Charro, E. (2014). A comparative analysis of stakeholders' views on science education from five different partner countries – results of the second round of the International PROFILES Curricular Delphi Study on Science Education. In C. P. Constantinou, N. Papadouris, & A. Hadjigeorgiou (Eds.), *E-Book Proceedings of the ESERA 2013 Conference: Science Education Research For Evidence-based Teaching and Coherence in Learning. Part 8* (pp. 185–196.) (co-ed. M. Ossevoort, & J.A. Nielsen), Nicosia, Cyprus: European Science Education Research Association.

4.10 Bio or Non-bio? – What Should I Choose?

Silvija Markic, Felix Henning – University of Bremen; Sibylle Wohlfeil – Oberschule Findorff; Ingrid Wolters – Wilhelm-Olbers-Oberschule, Bremen, Germany

Abstract

This poster presents a collaborative curriculum development case study from the PROFILES project in Bremen, Germany. The poster discusses the development of module by a team of science educators and in-service teachers from different schools, utilising a Participatory Action Research approach. The discussion is illustrated by a module answering the question "Bio or non-bio – what should I choose?" This module focuses learners' efforts on various experiments concerning different ions in fertilizer. The module is embedded in a socio-scientific issue as per the PROFILES approach, namely the problem of buying bio or non-bio products. Findings which emerged from the testing and evaluation process are presented. The results represent the justified points of view of the teachers, researchers and students participating in the study.

Introduction

In the last years school reform has taken place in the German Federal State of Bremen. The biggest change is that now two types of schools exist: (i) grammar schools (Gymnasium) and (ii) secondary comprehensive schools (Oberschule). Approximately 75% of all schools in the Federal State of Bremen are Oberschule. However, grammar schools have a longer tradition in Bremen. Thus, there is much more teaching materials in this direction available. On the other hand, Oberschule now offer a new governmentally mandated curriculum, where the biggest change is that science is now being offered as an integrated subject until grade 9 (age 13–14). Until this point, science was taught only in grades 5 and 6. Thus, science is a new subject in German schools. Teachers have not been educated to teach this new integrated science subject, with most only having studied one or two of the three traditional science subjects (biology, chemistry and physics). Also teaching materials for integrated science are very rare in Germany.

Starting from this point, the PROFILES group in Bremen aims to develop teaching materials for integrated science lessons in the Oberschule. Different groups of science teachers and science educators are developing new lesson plans, which fit the new curriculum for Bremen Oberschule. The present paper is based on a module developed within the framework of the PROFILES project. The module is focused on analysis of food and experiments concerning different ions in fertilizers. The module is embedded in a socio-scientific issue as per the PROFILES approach, namely the problem of buying bio or non-bio products. It fits the Bremen Oberschule curriculum for grade 7 (age 12–13). The development of the background of the module, the module itself and the evaluation of its implementation, are presented.

Development of the module

The development of the module is enacted through Participatory Action Research (PAR) in science education as described by Eilks and Ralle (2002). PAR is a joint effort between teachers and science educators for curriculum development, educational research, and classroom innovation. More details are presented in Figure 1.

The module on the question "Bio or non-bio – what should I choose?" was developed by a group of three chemistry/physics/biology teachers, who collaborated with a university researcher in a PAR project within PROFILES. Furthermore, one master student also worked on development of the present module. The group met regularly, every three to four weeks, and worked on teaching materials and the development of experiments. Additionally, since one of the teachers was not a chemistry teacher, she also tried the experiment on her own to develop her experimental skills within chemistry. The main focus of the group meetings was on changes in teaching practice, negotiation about it and refining it so that they could be tested and applied in classroom situations, before being reflected upon and improved.

Description of the module

The module was developed following the ideas of socio-critical and problem-oriented approaches to chemistry teaching, as described by Marks and Eilks (2009). More detail on these approaches can be found in Figure 2. These approaches were deemed sufficiently close to the PROFILES 3-stage model, so as to be taken to be the same (see Bolte et al., 2012; Holbrook & Rannikmäe, 2010; 2012).

During the initial textual approach and problem analysis, students observed different apples and wrote some characteristics about it. Finally they decided which one they would like to buy and why. At the end of the first lesson, the question arose why the apples were different in the first place. Following this, the students worked on clarifying the chemistry background in a laboratory environment. Students evaluated different fertilizers and the ions within them. They also obtained information about why the plant needed any particular ion. Starting from here, the focus was on phosphate and nitrates and their influence on nature, plants and human.

In the next phase, students prepared for a discussion through a role play. In the role play, five roles were presented, with each standing for a different viewpoint about using fertilizer in the fields and consuming bio or non-bio products. Finally, students reflected on the role play and the module itself.

Implementation and results

The testing and evaluation phases took place in four learning groups (grade 7; age 12–13) with a total of 79 students. The four groups were continuously accompanied and observed by university researchers. After each module was finished, self-reflection was performed by the

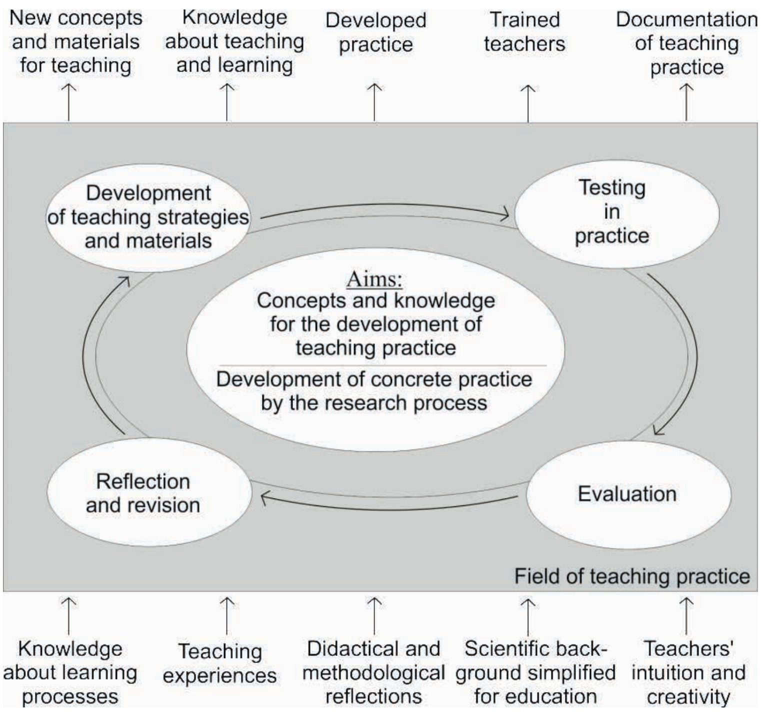


Figure 1. Model of Participatory Action Research (Eilks & Ralle, 2002)

teachers and documented using narrative reports. These experiences were regularly discussed by the entire PAR group. All students took a cognitive test and were asked to fill in a student feedback tool, consisting of a combination of both an open and a Likert-type questionnaire, as well as the MoLE questionnaire.

The teachers liked the idea of student-centred teaching module. They were happy with the product they produced, with the openness of the lessons and with the overall motivation of their students. This was also confirmed by the students` feedback. The students judged the lessons to be remarkably good. The students said that they had more fun during the present module than in other lessons. This statement was also supported by the MoLE questionnaire. Especially they enjoyed the role play at the end of the module. The teachers were surprised about this, since a role play was a new method for those students. However, only 50% of the students stated that the module made them think more critical about bio and non-bio products and to pay more attention to this issue while consuming different products.

Concept of the socio-critical and problem-oriented approach to chemistry teaching

Objectives	Criteria for selecting issues and apporaches	Methods	Structure of the lesson plans
Allgemeinbildung/ education through science	Authenticity	Authentic media	1. Textual approach and problem analysis
(Multidimensional) Scientific Literacy	Relevance	Student oriented chemistry learning and lab-work	2. Clarifying the chemistry background in a lab environment
Promotion of evaluation skills	Evaluation undetermined in a socio-scientific respect	Learner centred instruction and cooperative learning	3. Resuming the socio-scientific dimension
Promotion of communication skills	Allows for open discussion	Methods structuring controversial debating	4. Discussing and evaluating different points of view
Learning science	Deals with questions from chemistry and technology	Methods provoking the explication of individual opinions	5. Meta-reflection

Figure 2. Socio-critical and problem oriented approach in chemistry teaching (deemed to be very similar to the PROFILES 3-stage approach)

When students were asked about the learning content, about 70% stated that they liked the idea that the content was "hidden" in the module. They said that it made it more interesting. When it came to the cooperative learning, students liked the idea of teaching other students and being responsible for their own and the other students' knowledge. The results of the MoLE questionnaire supported this point as well.

Finally, the expectations of the teachers, which had been set down in the form of a pre-structured test, were exceeded by the students, most of whom achieved unexpectedly positive cognitive results.

Conclusions and implication

The module developed was a new experience for the students and the teachers, since it was focused on integrated science, a social-critical and problem-oriented issue, and was strongly student-centred. However, the evaluation showed that students were able to work and learn with the newly created teaching materials in this module on bio or non-bio food. The module made student think more consciously about the environmental problems and issues, and about these particular issues, even if it was only for a short time during the lessons.

Cooperative efforts between science teachers and teacher educators appear to offer attractive possibilities for developing new teaching materials in chemistry/science lessons. Furthermore, cooperation between experts stemming from multiple disciplines seems to offer a promising path for creating motivating and highly attractive learning environments, which allow science teachers to use successfully socio-critical and problem-oriented approach in PROFILES science teaching (e.g. Eilks, Markic & Witteck, 2010). Finally this indicates that the work of the group is a promising way of conducting CPD (e.g. Eilks & Markic, 2011; Mamlok-Naaman & Eilks, 2012).

References

Bolte, C., Streller, S., Holbrook, J., Rannikmäe, M., Hofstein, A., & Mamlok-Naaman, R. (2012). Introduction into the PROFILES project and its philosophy. In C. Bolte., J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 31–42). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Eilks, I., & Markic, S. (2011). Effects of a long-term Participatory Action Research project on science teachers' professional development. *Eurasia Journal of Mathematics, Science and Technology Education, 7*, 149–160.

Eilks, I., & Ralle, B. (2002). *Participatory Action Research in Chemical Education*. In B. Ralle & I. Eilks (Eds.), *Research in Chemical Education – What does it mean?* (pp. 87–98). Aachen: Shaker.

Eilks, I., Markic, S., & Witteck, T. (2010). Collaborative innovation of the science classroom by Participatory Action Research – Theory and practice in a project of implementing cooperative learning methods in chemistry education. In M. Valenčič Zuljan & J. Vogrinc (Eds.), *Facilitating effective student learning through teacher research and innovation* (pp. 77–101). Ljubljana: University of Ljubljana.

Holbrook, J., & Rannikmäe, M. (2012). Innovative inquiry-based science learning environments in the framework of PROFILES. In C. Bolte, J. Holbrook, & F. Rauch. (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 52–55). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Holbrook, J., & Rannikmäe, M. (2010). Contextualisation, de-contextualisation, recontextualisation – A science teaching approach to enhance meaningful learning for scientific literacy. In I. Eilks & B. Ralle (Eds.), *Contemporary science education* (pp. 69–82). Aachen: Shaker.

Mamlok-Naaman, R., & Eilks, I. (2012). Different types of Action Research to promote chemistry teachers' professional development – A joined theoretical reflection on two cases from Israel and Germany. *International Journal of Science and Mathematics Education, 10*(3), 581–610.

Marks, R., & Eilks, I. (2009). Promoting scientific literacy using a socio-critical and problem-oriented approach to chemistry teaching:

Concept, examples, experiences. *International Journal of Environmental and Science Education, 4*(2), 131–145.

4.11 Science Teaching that Goes Under Your Skin: A PROFILES Module on Tattooing

Marc Stuckey, Martin Haverkamp, Stephan Kienast, Ute Knoop, Bettina Most, Herbert Schultheis, Ulrike Willeke, Torsten Witteck, Petra Wlotzka & Ingo Eilks – University of Bremen, Germany

Abstract

This paper describes a teaching and learning module concerned with the subject of chemistry involving the topic of tattooing which was developed within the PROFILES project in Bremen, Germany. Some easy, hands-on experiments were developed to inquire into tattoo inks of different qualities. A classroom scenario is suggested for implementing these experiments in junior high school science classes. The lesson plan also involves a societal perspective on the practice of tattooing with a special focus on the interests and lives of the students. The module led to positive effects on student motivation and their perception of relevance of science teaching.

Introduction

Many popular musicians and sport stars wear tattoos. These celebrities act as role models and idols for the young generation. The latest tattoos worn by the stars are discussed, e.g. in teenage magazines, and influence teenagers and their views towards tattoos. In Germany, more than 20% of the 14 to 24 year old age group wears a tattoo. In the US, more than 20% of the total population has such body art. Estimates for the Western world infer that over 100 million people have let themselves be tattooed. However, related studies have shown that tattoos are not free from health risks. Tattoo inks contain a wide variety of chemical compounds, some of which represent risks to the body, such as azo dyes, polycyclic aromatic hydrocarbons and heavy metals compounds. Some countries, like Germany, have now introduced stricter rules and regulations for tattooing and tattoo inks. However, it is still easy to order tattoo colors through the Internet which do not comply to these regulations. For more details and corresponding references see Stuckey and Eilks (2014).

In this paper, it is suggested that the topic of tattooing can provide a motivating context for science education. The practice of tattooing is authentic, relevant, controversial, and can be openly discussed among high school students. These represent the basic criteria for promising socio-scientific issues that have the necessary potential for motivating learning environments in science education (Stolz, Witteck, Marks & Eilks, 2013). Therefore, in the PROFILES project in Bremen, Germany, a group of teachers developed a teaching and learning module based on the topic of tattooing aimed at junior high school level.

Development and structure of the module

Within the PROFILES project in Bremen, Germany, a group of eight teachers developed a teaching and learning module on tattoo inks, their respective properties and the potential societal and health implications of having a tattoo (Stuckey & Eilks, 2014). Using the idea of filtered information and mimicking authentic societal practices of information transfer (Eilks, Nielsen & Hofstein, 2013) the module starts by analyzing the use of science in teenage magazines. In a fictive self-test – as it is typical for this kind of magazines – students are asked to reflect on their own views towards tattooing. The students also differentiate between personal, societal and scientific questions in the test and to recognize controversial arguments. Starting from this activity, the students are directed towards inquiring into different kinds of tattoo inks. One sort of inks is approved according to legal regulation for tattoo inks in Germany, the other sort, much cheaper, can be ordered via Ebay from south-east Asia. The inks differ significantly in the comprehensibility of their labels, thermal stability, or pigment size. Several easy, hands-on experiments can be developed in which students can examine the various inks and identify the differences. Students can also test whether a tattoo ink can be toxic to plants or inhibits enzymes.

Finally, the students simulate another societal practice inspired by teenage magazines. They are required to answer a fictive letter sent to the editor in which a teenager asks for advice concerning getting a tattoo, although the parents refuse permission to have one. The module takes four lessons, each being 45 minutes long. It was structured to align with the socio-critical and problem-oriented approach for science education developed by Marks and Eilks (2009). This approach parallels the PROFILES 3-stage model (Holbrook & Rannikmäe, 2010), but puts strong emphasis on reflecting on practices of use and potential misuse of scientific information in society. Table 1 provides an overview on the module.

Step	Task
Textual approach and problem analysis	- Mimicking a self-test page from a commonly known youth journal ("What kind of tattoo person am I?") - Reflection on the different perspectives found in the self-test: aesthetic, societal and science-related - Developing questions to inquire into the chemistry background of the issue
Clarifying the chemistry background in a lab environment	- Carrying out various inquiry-based experiments on tattoo inks from different sources such as flame colouration test, particle size, enzymatic activity, stability, solubility etc.
Re-examining the socio-scientific dimension of the topic	- Reflecting upon which scientific aspects of the topic were answered in the laboratory and which were not
Discussion and evaluating different points of view	- Mimicking the editorial consulting function found in youth journals by responding to a fictitious letter from a teenager who wants to get a tattoo - Presentation of the various replies to the letter and reflection on why chemistry-related arguments were or were not chosen
Meta-reflection exercise	- Reflection upon exactly which role science-related information plays in the youth media with regard to both self-tests and consulting readers

Table 1. Overview of module on tattooing (Stuckey & Eilks, 2014, p. 161)

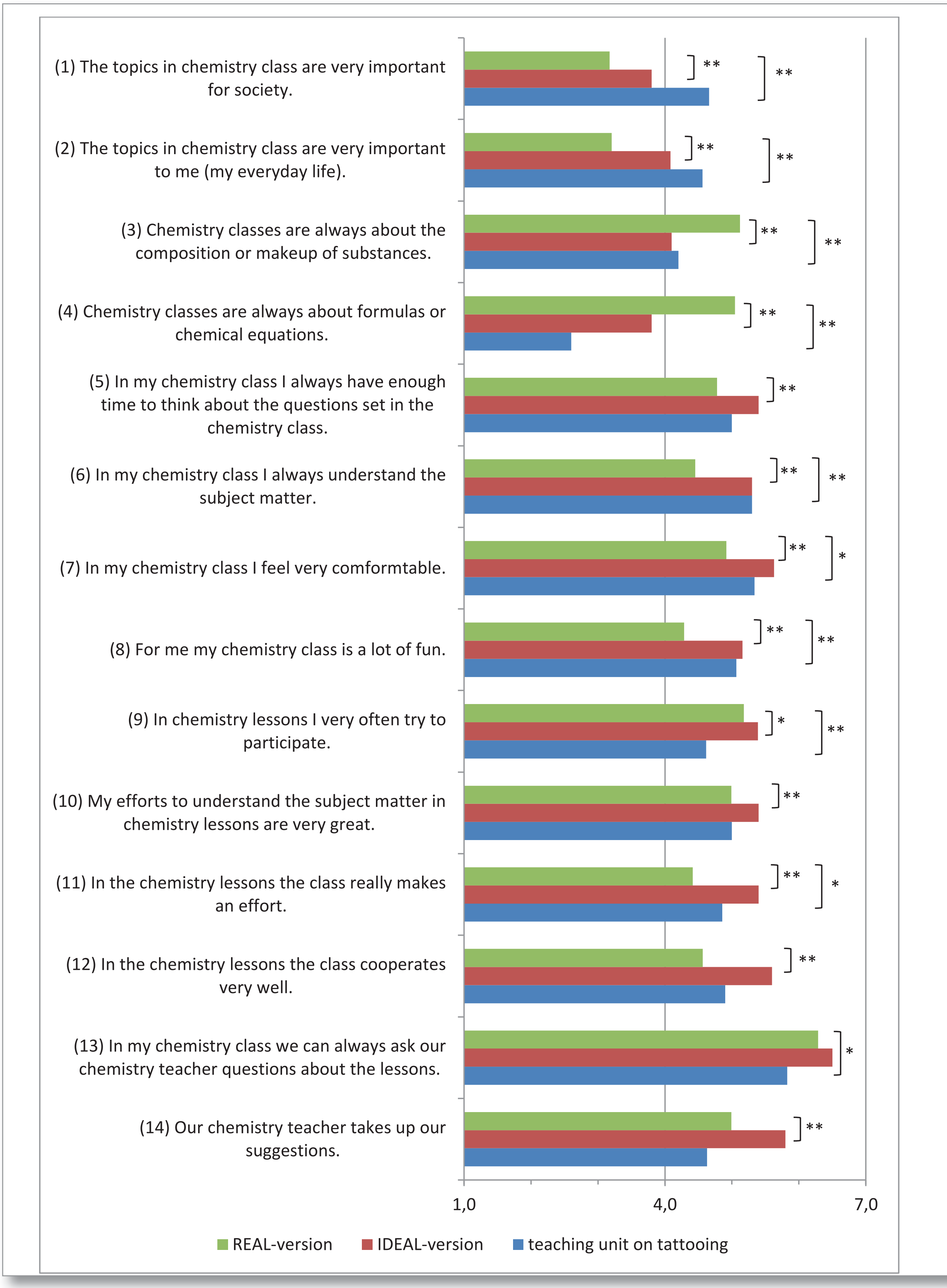


Figure 1. Results from the MoLE questionnaire for the module on tattooing (: p<0.05; **: p<0.01, N=108) (Stuckey & Eilks, 2014, p. 164)*

Effects of the module

The module was developed by a group of eight teachers following a Participatory Action Research approach to science education by Eilks and Ralle (2002). For about one year, teachers and curriculum experts met regularly once a month for three hours to discuss the development of the module. Pre-testing of the materials took place in three upper secondary school chemistry classes (age 17–18 years) before the final lesson plan for junior high school level (age range 14–15) was structured.

Effects on motivation and perception of relevance were researched in a case with four learning groups and a total of 108 students from a comprehensive school in Northern Germany. Different instruments were used, such as teacher self-reflection, a student feedback questionnaire and the MoLE (Motivational Learning Environment) instrument as described in Bolte, Streller and Hofstein (2013). This last part of the study was the focus of discussion here.

The data from the MoLE instrument showed that the topic led to highly significant changes in the students' level of motivation. This was mainly due to the perception of relevance of the topic (Stuckey & Eilks, 2014). It seems that this module satisfied students' wishes regarding science teaching (Figure 1). The analysis of the questionnaire shows that in some issues the lesson plan on tattooing was even better judged by the students than the students wished their science lessons to be (which they stated before the lesson plan had started).

Conclusions

Tattooing as a socio-scientific issue for science education proved to be highly relevant to the students. Operated according to the PROFILES philosophy of inquiry-based and societal-oriented science teaching (Holbrook & Rannikmäe, 2012), the module helped raising students' motivation in science lessons. Reflections on the case study indicated that it was basically the authenticity and relevance of the topic and the sharing of social communication processes that made science education in this example so motivating in the eyes of the students.

References

Bolte C., Streller S., & Hofstein A. (2013). How to motivate students and raise their interest in chemistry education. In I. Eilks & A. Hofstein (Eds.), *Teaching chemistry – A studybook* (pp. 67–95). Rotterdam: Sense.

Eilks, I., Nielsen, J. A., & Hofstein, A. (2014). Learning about the role of science in public debate as an essential component of scientific literacy. In C. Bruguière, A. Tiberghien, & P. Clément (Eds.), *Topics and trends in current science education* (pp. 85–100). Dordrecht: Springer.

Eilks, I., & Ralle, B. (2002). Participatory Action Research in chemical education. In B. Ralle & I. Eilks (Eds.), *Research in Chemical Education – What does it mean?* (pp. 87–98). Aachen: Shaker.

Holbrook, J., & Rannikmäe, M. (2010). Contextualisation, de-contextualisation, re-contextualisation – A science teaching approach to enhance meaningful learning for scientific literacy. In I. Eilks & B. Ralle (Eds.), *Contemporary science education* (pp. 69–82). Aachen: Shaker.

Holbrook, J. & Rannikmäe, M. (2012). Innovative inquiry-based science learning environments in the framework of PROFILES. In C. Bolte., J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 52–55). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Marks, R., & Eilks, I. (2009). Promoting scientific literacy using a socio-critical and problem-oriented approach to chemistry teaching: Concept, examples, experiences. *International Journal of Environmental & Science Education, 4*, 231–245.

Stolz, M., Witteck, T., Marks, R., & Eilks, I. (2013). Reflecting socio-scientific issues for science education coming from the case of curriculum development on doping in chemistry education. *Eurasia Journal of Mathematics, Science and Technological Education, 9*, 273–282.

Stuckey, M., & Eilks, I. (2014). Raising motivation in the chemistry classroom by learning about the student-relevant issue of tattooing from a chemistry and societal perspective. *Chemistry Education Research and Practice, 15*, 156–167.

4.12 PROFILES Impact! Not Only CPD: From the CPD to the Class, From the Class to Chemistry Competitions

Sofia Leyderman – Kfar Silver High-School & Ort Rogozin High-School, Kiryat-Gat, Israel
Advisors: Dvora Katchevich, Malka Yayon, Rachel Mamlok-Naaman & Avi Hofstein – The Weizmann Institute of Science, Rehovot, Israel

Abstract

Sofia, a chemistry teacher, was involved in a PROFILES CPD programme at the Weizmann Institute in Israel for three years and this has helped her in enhancing the motivation and pride of her students. In this article, Sofia described how the implementation of the modules that she developed "ignited" her students' motivation. After the implementation of the first module "Hazard from above: Which sunscreen should we choose" she suggested her students submit a short video based on their module to the national competition, held annually at the Weizmann Institute "We've got chemistry." Her students won! The following year she didn't have to suggest anymore; her students asked to join the competition on inquiry and won! The same happened the following year. She hopes that this paper will promote similar activities among PROFILES teachers in other countries.

Description of the process: from the CPD to the classroom; from the class to Chemistry competitions.

Every year I have suggested to my students to participate in the national competition in chemistry that focused on the "chemistry of everyday life and the chemical industry." In the last three years, my students have chosen to take part in these contests after the implementation of the PROFILES approach in class, and had won. In this article I have described how it all began at the CPD workshop, where we developed the modules, through the implementation of the module in the classroom, and from the classroom to the students, and finally to the competitions.

I have participated in all three cycles of the PROFILES professional development workshops (Bolte, Holbrook & Rauch, 2012). Immediately after being exposed to, and experiencing an existing module, during a CPD session held in summer of 2011, I became very excited – I really wanted to continue to participate in the workshop and to design my own module in collaboration with my colleagues – high school chemistry teachers like me. The development process included collaboration with colleagues and was guided by professional development providers. The development and implementation of the module was accompanied by a presentation of the module at various stages. These presentations initiated various constructive discussions with other teachers; in choosing a topic, suggesting relevant activities and experiments and other information, I really felt like a student who was undergoing a significant and interesting learning experience and I wanted my own students to sense and undertake similar experiences.

In the first year we[1] developed a module on "sunscreen". The module began with an opening scenario in which students observed TV commercials regarding different types of sunscreens, followed by a brainstorming activity during which students raised various concepts regarding relevant sunscreens. Students were asked to perform a web search to gather information related to these concepts. The students shared the information collected from the web search, the teacher added information, organized and summarized the knowledge gained.

After learning the basic concept related to sunscreens and preparing a cream, each group

[1] Hazard from above! Which sunscreen should we choose? Boaz Hadas, Sofia Leyderman – Ort Rogozin High-School, Kiry-at-Gat, & Dr. Irina Raiman – Ein Karem High-School, Jerusalem

designed and prepared a sunscreen. For example, one group chose to investigate the effect of the thickness of the cream layer on the capability (effectiveness) of sunscreen lotion to protect UV absorption by sensitive beads. Following these activities the students performed a product/market survey which gave the module a social dimension. All these activities guided the students to a finale in which they needed to decide which sunscreen they should use.

I implemented the module in a number of 10th grades and one 12th grade class (age 15–18). There was enthusiasm and students asked to study other topics in this way. Combining research with social aspects and decision-making seemed to appeal to my students. I suggested my students to take part in the national competition held annually at the Weizmann Institute "We've got chemistry – Chemistry in daily life, society and industry" (Sharaabi-Naor, in press). There were various categories in which students could compete: articles, photographs, posters, inquiry and videos. A group of 12th grade students chose to make a video on sunscreens, the theme of the module. They won second prize in the competition's video category. The news was spread among their peers, at school and we posted it on the school website and in the local newspaper of Kiryat Gat.

Figure 1. Sofi, the teacher receiving the prize with her students

A year later, in another school where I worked, I implemented again the module on sunscreen. Students in this class volunteered to participate in the competition, but chose to focus on inquiry, based on the cream itself, and they studied the characteristics of the emulsion obtained by mixing the components of the cream. Their research question related to how the homogenizing time affected the stability of the cream. Advanced equipment for research, such as the homogenizing machine, was provided by a local factory producing creams. This team won second prize in the category of inquiry projects.

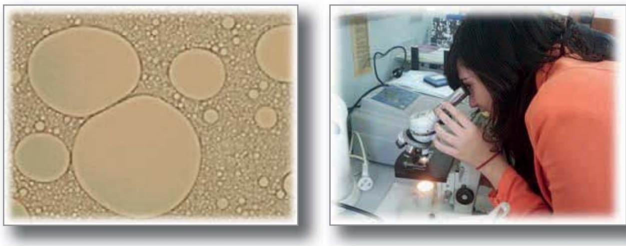


Figure 2. Left: a microscopic view of the first stages of the emulsion Right: Dorit, one student, analyzing the sample in the factory

Figure 3. The students, Dor and Dorit, receiving the prize

In the following year, I participated again in the PROFILES professional development workshop. Some students asked me to develop a module on ice cream and so I developed a new module, with another partner, called "We research: ice cream." I implemented the module in a number of classes, after adapting it to the target population. In the opening scenario of the module, the entire class prepared ice cream by playing with a special ball. The ball was a simple cooling system which contains two compartments: in the middle one the ice cream mixture was cooled by another container that wrapped around it; this container was filled with a mixture of ice and salt. While throwing the ball, the materials were mixed and cooled down until the "solidification" ice cream and students could brainstorm and suggest questions related to ice cream. After this activity students made a web search to gather information related to ice cream;

they made ice cream in small quantities in test tubes (Figure 4) and were asked to suggest research questions on the subject. Students planned, performed their experiment and conducted a survey to examine preferences of the population regarding ice cream types, depending on age groups. Finally, students choose their favorite ice cream according to relevant, self-devised criteria.

This year one group, turned to me and asked if they could participate in the competition, in the inquiry category. This group chose to explore how the fat percentage in ice cream influenced the melting time of the ice cream. They measured the time the ice cream took to begin to drip (the system is shown in Figure 4). This group won first prize and the judges commended the simple technique for measuring the melting point.

Figure 4. The experimental equipment to answer the research question

Finally, from my point of view, my participation in the PROFILES professional development workshop achieved its goal. As a teacher, I have felt I've progressed regarding the diversity of teaching methods and pedagogy. I met colleagues with whom I remain in contact, not only related to PROFILES, but also on chemistry and broader social contexts. Last but not least, my students gained, because I could excite and engage them; I could ignite the light of curiosity in their eyes; they liked science in general and chemistry in particular. The feedback that I received from students and their parents was very flattering. Winning prizes enriched and enhanced the pride of the students majoring in chemistry in the schools in which I taught.

Figure 5. The group at the final stage of the competition

Figure 6. The group at the award reception

We sincerely hope that this paper will promote similar activities among PROFILES teachers in other countries (Hofstein, Mamlok-Naaman, Katchevitch, Rauch & Namsone, 2012)

References

Bolte, C., Holbrook, J., & Rauch, F. (Eds.). (2012). *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project.* Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Hofstein, A., Mamlok-Naaman, R., Katchevitch, D., Rauch, F., & Namsone, D. (2012). Teachers' ownership: What is it and how is it developed? In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-*

based Science Education in Europe: Reflections from the PROFILES Project (pp. 56–58). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Sharaabi-Naor, Y., Kesner, M., & Shwartz, Y. (in press). Enhancing Students' Motivation to Learn Chemistry. *Sisyphus Journal of Education*.

4.13 Edible Chemistry: Food for Thought Development & Implementation of Two PROFILES Modules in Israel

Batia Lifshitz-Goldreich – Yigal Alon Comprehensive High school for the Arts and Sciences, Ramat Hasharon
Adina Arbel, Bondi Yael & Halfon Emi – Branco-Weiss Rabin High School, Mazkeret-Batya
Sharon Deutsch – Shoam High-School, Shoham
Smadar Aharoni-Gerbat – Yarkon High-School, Neve-Yarak, Israel
Advisors: Dvora Katchevich, Malka Yayon, Rachel Mamlok-Naaman & Avi Hofstein – Weizmann Institute of Science, Israel

Abstract

Two PROFILES modules, "Oil of Life – Is Olive Oil the best oil?" and "Dark, Milk or White – Which Tastes Better?" were developed by Israeli science teachers participating in the PROFILES teachers' professional development programme, initiated by the Science Teaching Department at the Weizmann Institute of Science. The described modules were developed according to the principles and rationale of the PROFILES project. According to the philosophy and rationale of the project, the approach is student centered. It includes inquiry-based activities, which contribute to decision-making in relevant topics related to everyday life; more specifically to the chemistry of food. The modules emphasize the use of inquiry skills, by traditional activities such as acquiring information on the web, or through research experiments conducted in the chemistry lab and other activities that direct the students towards social research by performing a market poll about the product. The modules were adapted for implementation to various target population groups. Positive feedback from teachers and students provide evidence for effective implementation. The module's teacher's guide presents the sequence of teaching activities; it includes student activity sheets, a review of the relevant scientific background, and also allows teachers to assess students' activities. The role of the teacher as an activity coordinator is altered. Rather than the teacher's classic role in frontal teaching, the students play a central role in this educational programme. Nevertheless, the importance of the teacher's involvement in directing and initiating discussions throughout the module, as well as broadening & adding relevant knowledge to the subject, is emphasized.

First module: "Oil of Life – Is Olive Oil the best oil?"

Introduction – Olive Oil is made from olives, and is *considered the best oil*, better than corn, soya, sunflower oil etc. Olive oil has been recognized for many years as healthy oil, containing important components. It is often referred to as: *"Liquid Gold"*. It is a favorite among chefs, nutritionists and is also a staple food in the healthy, Mediterranean diet, especially in Israel. From a social and educational perspective, this module examines what people know about the olive oil that is used in salad dressing. Students learn many facts about oil, such as – oil may cause weight gain, but "olive oil" has nutritional values as well.

From a scientific perspective of chemical education, the subject allows one to teach topics such as: experiments to determine the percentage of free fatty acids, as well as finding and deciding what criteria are relevant for choosing proper salad dressing oil. In the Olive Oil module the students have to make decisions regarding the quality of the olive oil at home, based on the examination of scientific knowledge that brings the world of chemistry, relevant to the student's world.

Overview of the module – contents

The module was integrated into the sequence of the learning programme on the subject of materials and human nutrition in junior high school (9^{th} grade). One of the aims of PROFILES is to impact on students' critical, socio-scientific decision-making. This compelled us to build a certain sequence of activities that lead them to achieve this goal.

The students' activities are as follows:

Beginning scenario – The goal of the first activity is to present the subject in a way in which the students' curiosity focuses on the subjects in question, and enables the students to obtain a general understanding of olive oil.

Exposing the subject to the students by use of a video clip – Students then gather data, via questionnaires, on the preferred type of oil used in their homes, and determine if a preference for olive oil exists.

Market research – The goal of the second activity is to allow the students to reveal the scientific and social aspects of the subject and to motivate them to inquire further. This involves designing a survey aimed at comparing the products available on the market, or conducting a consumer survey. Students define by themselves the objectives of the survey, but receiving specific guidelines concerning the requirements of the assignment; this includes methods, results, and conclusions.

Research laboratory – The goal of this part is for students to acquire research skills, and to learn the subject in an experiential way.The students conducted an experiment to determine the percentage of free fatty acids in olive oil (which is one of the criteria of the quality of oil) to verify the information on the nutritional labels.

Decision making – Students write a summary of the module, which relates to various aspects learned on the subject throughout the task, and refer directly to the process of making a decision about which oil to buy.

Evaluation of student through the process – The students present a group portfolio which is evaluated by criteria such as: compliance and quality of the different tasks required clarity and fluency of the scientific language, as well as the argumentation. The involvement of the students in the process is evaluated according to their personal reflection.

Implementation of the olive oil module & reflection on its value

The olive oil module was implemented, by the module developers. Adaptations to the module were made in accordance with the characteristics of the students chosen, specifically, their age, skills, and prior knowledge. All the students displayed excitement and enthusiasm about the versatile and alternative way of learning, which was evaluated differently. The students' interest and their high involvement in the process was evidence that the stucture and content of this activity met the targets that had been set.

Some of my students' reflections follow:

> *"Before studying this topic, I didn't know much about oil. I knew that there are different types of oil and that it's not healthy to use too much, but I didn't know all the phrases and explanations that I now know."*

> *"I started to see the oil that I use in a different way. I use healthier kinds of oil, and I read and understand what is written on the labels on the bottles of oil, as well as understand how they were produced and what they have in them."*

> *"I was successful in influencing my family regarding oil and its uses. I explained that it was better to use extra-virgin olive oil and the reasons for this. I could also explain and stress the fact that we shouldn't use too much oil and certainly not to fry food for a long time."*

Teacher's reflection

"The planning, development and implementation was made possible because of the close guidance we received."

"This teaching experience, which was out of the ordinary, was meaningful for us and enriched our experiences as educators."

"Using up-to-date technology (mainly smartphones) was important in bridging the technology gap between teacher and students."

"We had difficulties while doing the experiment and the programme developers found a solution."

Figure 1 and 2. Students investigating the labels of the oil bottles and perform a web search using their smartphones

Second module: Dark, milk, or white – which tastes better?

Introduction – Have you ever thought about questions such as: How is chocolate made? What kind of chocolate is the best? In this module, the students enter the magical world of chocolate. They prepare chocolate, and decide which kind tastes best, while identifying their criteria which helped them make a decision. The module includes activities designed to allow the students to find out different aspects of the product known as chocolate – the production process, kinds, composition, and other interesting facts. The theme „Chocolate" provides a proper platform to teach concepts such as chemical compounds, homogeneous and heterogeneous mixtures, and colloid mixtures (chemical education) as well as inquiry skills such as: Asking and phrasing inquiry questions, and conducting related experiment. From a social and educational perspective, this module is aimed to rational and logical decision-making process.

Overview of the module-contents

The module was integrated into the learning the programme on the subject of mixtures and chemical compounds in 9th and 10th grades. The following sequence of activities lead the students to critical decision-making, related to chocolate.

Introduction – The first activity exposes the subject of the module "chocolate" to the students by a short video clip demonstrating chocolate preparation; preparing chocolate in class, following the instructions showed in the clip. The goal of the first activity is to present the subject to the students in a way in which the students' interest and curiosity is aroused to engage them.

Experiment planning – In the demonstration, chocolate is prepared by mixing four ingredients – cocoa powder, milk powder, sugar powder and margarine. The students are asked to raise questions related to chocolate preparation. The goal of the second activity is for the students to acquire research skills dealing with planning an experiment.

Expanding knowledge – In order to expand knowledge regarding chocolate, each group of students chooses one topic that interests them, and finds relevant information in the web. The goal of this third activity is to allow the students to learn new aspects and interesting information about chocolate.

Displaying the knowledge – Each group presents the topic selected to the class. The guidelines are that the presentation needs to be creative and interesting. Each group can present a short lecture, a quiz, a game, or any other method they choose.

The goal of the fourth activity is to let the students experience a short presentation in front of their classmates and hence develop presentation skills.

Conducting the experiment – After the students experimental suggestions have been approved by the teacher, they carry out their experiments and write conclusions. The goal of the fifth activity is to acquire research skills dealing with performing and analyzing the experiment.

Making decisions – Each student tastes all of the chocolates in a blind test and rates them between 1 and 5 according to a common criterion such as taste, color, shape, texture, gloss, etc., and to find out which is the preferred chocolate by the students in the class as a whole. The students discuss the different perceptions and endeavor to come to a class consensus.

Finale – A video about the production of chocolate from cocoa beans is presented.

Assessment – For the assessment, each group hands in a portfolio containing all their activities and an individual reflection provided online by a QR-code (Figure 3) by each member of the group.

Figure 3. QR code for online reflection after the implementation

Implementation of the chocolate module & reflection on its value

The chocolate module was implemented, by those teachers who developed it, in three different high schools. Adaptations to the module were made in accordance with the characteristics of the students chosen, specifically, their age, skills, and prior knowledge. All the students in the different groups displayed excitement and enthusiasm about the versatile and alternative way of learning, which was evaluated differently. While exploring the internet, the students were excited to identify various interesting facts about chocolate, such as chocolate can be healthy, and that the blood in the colorless "Psycho" film by Hitchcock was made of chocolate.

Students prepared various kinds of chocolate by changing the amount and kind of sweetener (honey/sugar/liquid sweetener), the amount and kind of cocoa, milk powder, or fat. Some added nuts or raisins and checked the effect on the taste and texture of the chocolate.

Figure 4 and 5. Students presenting their chocolates and poster

Teaching the chocolate module at my school was divided into 6 lessons, and it was seen as the highlight of the educational activity in the chemistry class all year long. From the curricular point of view – the module was an interesting supplement and excellent conclusion to the 10th grade chemistry syllabus and the interest shown by the students made me realize that I made the right decision. I feel that allowing my students to study in a different way, to be creative, involved and inquisitive – raised the level and quality of the educational activity in class and made the activity fun to my students.

Students' reflections

> *"I loved this way of learning chemistry by using my phone for answering questionnaires and viewing the immediate results, conducting lab experiments and tasting the results."*

> *"I loved the subject of this activity. It is close to my everyday life. By thinking which kind of chocolate to prepare we learned how to ask research questions, and how to prepare and conduct a lab experiment. I really enjoyed the lab experiments."*

> *"I learned that there was much more to chocolate than I thought."*

We really enjoyed developing the module. We learned a lot, from the steps required for developing it, through the difficulties faced by unit developers, and in adapting the module to all sorts of students. We are happy to see that many teachers have chosen to implement this module in their classrooms and that many teachers acknowledged our intense work for developing a new way of teaching and learning, the PROFILES rationale.

To sum-up, we like to introduce more teachers to the option of integrating PROFILES modules into their science education curriculum. We think it is important that teachers recognize the possibility of upgrading the educational work and classroom teaching by various means. We intend to share this experience with other teachers in our school, and to share the modules with the rest of the community of chemistry teachers.

4.14 A Renaissance Enigma: Raphael and the Lustre Technique

Daniela Ambrosi – Liceo Scientifico Galileo Galilei, Perugia, Italy

Abstract

After years of teaching I thought I knew well what students expected when coming to my lessons. The level of my teaching was considered good by my headmaster: the students were interested and their parents happy with what students learned. Nevertheless, the philosophy of the PROFILES project has brought me new ideas and ways to involve and interest the most of my students. The teaching experience reported here unfolded in three years and was a very engaging and positive experience for my students. In the study of Deruta pottery, chemistry has been the tool for discovering links between history, art, and nanotechnology, and the interacting with peers in cooperative groups. In this project, the students were the protagonists of all phases of work, from planning to evaluation, and agreement with the students was a characteristic of the final power point presentations from each group.

Introduction

The PISA (Programme for International Student Assessment; http://www.oecd.org/pisa) study showed that over the last decade, students' interests and achievements in science have declined in Italy. According to Aikenhead (2003, p. 103), the reason was that

> *"chemistry and physics are irrelevant and boring, mainly because their instruction was out of synchrony with the world outside of school."*

A Delphi study provided a convincing explanation

> *"the lack in popularity was due to a gap between the expectations of science education and the educational interests of large sections of the population"* (Bolte, 2008, p. 333).

If the purpose is to get different results by our students, then it is necessary to teach in a different way. According to Osborne and Dillon (2008, p. 27),

> *"the primary goal of science education cannot be simply to produce the next generation of scientists. Rather, societies need to offer their young people an education in and about science – and that this needs to be an education that will develop an understanding of the major explanatory themes that science has to offer and contribute to their ability to engage critically with science in their future lives."*

Thus, a stronger societal orientation in science teaching remains a key demand for contemporary science education (Hofstein, Eilks & Bybee, 2011).

A change in the orientation of the teaching philosophy is necessary: from 'science through education' to 'education through science'.

> *"Science education should be regarded as, 'education through science' rather than 'education through science.' [...] This encompasses an understanding of the nature of science [education], with links to achievement of goals in the personal domain, stressing intellectual and communication skill development, as well as the promotion of character and positive attitudes, plus achievement of goals in the social education domain, stressing cooperative learning and socio-scientific decision-making."* (Holbrook & Rannikmäe, 2007, p. 1347).

This is why collaborative scientific argumentation and socio-scientific issues (SSI) have become important aspects in the field of science education.

A rich learning environment

A project was planned to teach chemistry at the high school, to interest and engage students and to develop problem-solving and critical thinking skills. Cooperative groups were formed and students learned to interact in a constructive way. The students were the protagonists of all phases of the work, from planning to evaluation, and always had a common purpose and shared goals. Students were responsible for the outcome: the success of the individual existed only in the presence of the team's success. Teams were composed of three or four students, with different roles and responsibilities. The discovery of the philosophy of the PROFILES' project enriched the project: a greater emphasis has been placed on the investigation and on the socio-scientific discussions (Bolte et al., 2012).

The project was developed in the years, 2011–2014, and involved four classes of students aged between 16 and 18 years old. The stimulus situation was given by the question: *Why has Raphael created a design for the ceramics of Deruta*? The students were encouraged to discover for themselves. They needed to discuss in groups, do research, both historical and artistic: this gave rise to many more questions to be discussed by the whole class. In this last school year, the demand stimulus has been: *What is the secret of lustre; what lies behind this Renaissance conundrum*? The rationale behind these questions had historical and chemical roots.

Figure 1. Plates with drawings similar to those designed by Raffaello for the Baglioni family

Students have reconstructed the events. Raphael was a painter, born in Urbino in 1483. Upon the death of his father, he moved to the richer area of Perugia: here among his clients was the Baglioni family, aristocrats in Perugia. In July 14, 1500 an important marriage between Astorre Baglioni and Lavinia Colonna was celebrated, with the aim of establishing the rise to power of the Baglioni family.

Figure 2. Fragments of pottery made by the lustre technique

The students discovered that lustre was an ancient technique of ceramic decoration, which, through the application of a mixture of clay diluted with vinegar and special firing in a reducing environment, produced iridescent color effects; yellow gold, ruby red silver. It has been recently shown that lustre decoration of medieval and renaissance potter that consists of silver and copper nano-crystals, dispersed within the glassy matrix of the ceramic glaze (Borgia et al. 2002). In fact, Romani et al. (2000, p. 121) found that

> *"the typical elements of lustre, Ag and Cu, were found along with those typical of the glaze (Pb, Sn) and paste (Si, Ca)."*

It was thus possible to explain the redox reactions and students in the laboratory carried out the Fehling test with reducing carbohydrates, and stoichiometric calculations, while for colloidal systems this was limited to the observation of milk with laser light. At this stage, many questions arose. Precisely, lustre became the subject of questions: What is it? How do you prepare it? The search moved to Deruta, where Raphael interviewed a master craftsman who produced pottery using the lustre technique.

A new problem arises: Not all clays are suitable for the lustre technique. In ancient times, place of extraction was secret and were handed down from father to son. A new question: What is the area of origin of the clay? How can a clay form, rich in the elements found in the study of Romani et al. (2000, p. 121)? Researches carried out at the Department of Earth Sciences, University of Perugia has allowed us to discover the place. This was followed by a social debate by students with hypotheses and arguments to explain the formation of this clay.

After the scientific research, we cooperated with the teacher of Literature in the construction of a theatrical script and the students built themselves a story board for the viewing of a movie. In the presence of parents, at the end of the school year, with presentation and viewing of a movie, there was great participation and especially gratification and enthusiasm from the students. As can be seen from the graph, the level of learning of the students was remarkable: the level of learning of redox, colloidal systems, stoichiometry, classification of minerals, was above average.

Conclusion

The students have been engaged in the study and have learned at home in an independent and well-structured way. As a consequence, the teacher has been able to devote class time to plan the work, to discuss, give suggestions, and argue, facilitating collaboration among students. The philosophy of the PROFILES Project (Bolte et al., 2012) has led me to reflect on my practice and to use socio-scientific discussions to enable students to argue using their scientific knowledge.

The argumentation in the classroom has value, because

> *"The variety and the nature of arguments which emerged, their interplay in the process of argumentation and in the process of decision-making are tools of thought, are not usually apparent in science or mathematics classrooms"* (Patronis, Potari, Spiliotopoulou, 1999, p. 752).

References

Aikenhead, G. S. (2003). Chemistry and Physics Instruction: Integration, Ideologies, and Choices. *Chemical Education: Research and Practice, 4*(2), 115–130.

Bolte, C. (2008). A Conceptual Framework for the Enhancement of Popularity and Relevance of

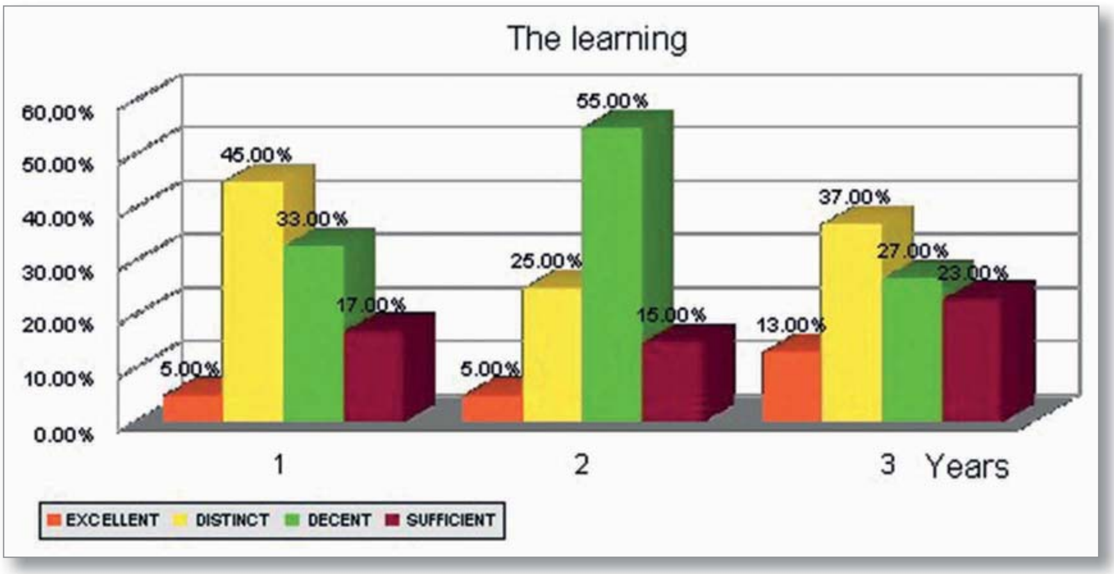


Figure 3. Level of learning of the students during the three years of development of this project

Science Education for Scientific Literacy, based on Stakeholders' Views by Means of a Curricular Delphi Study in Chemistry. *Science Education International, 19*(3), 331–350.

Bolte, C., Streller, S., Holbrook, J., Rannikmäe, M., Hofstein, A., Mamlok, R. & Rauch, F. (2012). Introduction into the PROFILES Project and its Philosophy. C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe. Reflections from the PROFILES Project* (pp. 31–42). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Borgia, I., Brunetti, B., Mariani, I., Sgamellotti, A., Cariati, F., Fermo, P., Mellini, M., Viti, C., & Padeletti, G. (2002). Heterogeneous distribution of metal nanocrystals in glazes of historical pottery. *Applied Surface Science, 185*(3–4), 206–216.

Hofstein, A., Eilks, I., & Bybee, R. (2011). Societal issues and their importance for contemporary science education – A pedagogical justification and the state-of-the-art in Israel, Germany, and the USA. *International Journal of Science and Mathematics Education, 9*(6), 1459–1483.

Holbrook, J., & Rannikmäe, M. (2007). The Nature of Science Education for Enhancing Scientific Literacy. *International Journal of Science Education, 29*(11), 1347–1362.

Osborne, J., & Dillon, J. (2008). *Science Education in Europe: Critical Reflections. A Report to the Nuffield Foundation*. London: The Nuffield Foundation.

Patronis, T., Potari, D., & Spiliotopoulou, V. (1999). Students' argumentation in decision-making on a socio-scientific issue: Implications for teaching. *International Journal of Science Education, 21*(7), 745–754.

Romani, A., Miliani, C., Morresi, A., Forini, N., & Favaro, G. (2000). Surface morphology and composition of some "lustro" decorated fragments of ancient ceramics from Deruta (Central Italy). *Applied Surface Science, 157*(3), 112–122.

4.15 With Flying Colours

Battistini Lorenza, Frattoni Pina, Gallina Anna, Celestina Crosa, Guardati Nadia, Lattanzi Cinzia, Stortini Silvia & Terzi Morena – IPSIA "RENZO FRAU" (Istituto Professionale di Stato per l'Industria e l'Artigianato), Tolentino
Katuscia Palmili – IPSIA "RENZO FRAU" (Istituto Professionale di Stato per l'Industria e l'Artigianato), Sarnano, Italy

Abstract

A positive educational experience in a vocational school was the subject of this report. In one class, students at the beginning of the school year, rejected lessons in some scientific subjects, and particularly so for chemistry. In response, a group of teachers of different subjects combined their skills to set out to achieve the goal of addressing the issue by involving and motivating the students. The desire of the students to participate in a national competition was the context that allowed the teachers to persuade the students to change their attitude towards school subjects. The approach could be defined as guided inquiry, where students were provided with many opportunities to make suggestions and propose solutions. The collaboration of several teachers for a common purpose provided the platform which allowed the change: students became motivated, interested, and above all there was a clear improvement in terms of learning knowledge. All teachers shared the need to actively involving the students and to use cooperative learning methods. Thus, students came to be involved in coloring and painting fabrics, designing, cutting and sewing shopping bags through an interdisciplinary approach across several subjects. The students carried out their experiences related to biology and chemistry in the laboratory; something unthinkable at the beginning of the school year. This project amazed and rewarded the teachers for all the work they had done. And at the end, the students won a prize in a national competition: their joy was great, and the school director was well satisfied with the outcome and the learning experience.

Introduction

Vocational schools are considered more difficult terrain than other schools because of the lack of interest and motivation by the students. Complaints, often repeated in the first days of school, are: "Why should we study these things?"; "What is chemistry?" "We don't need chemistry." The important experiences for students, i.e. significant learning and disciplinary aspects of human growth, as described below, show how it is possible to teach in a way that develops students' interest.

Several studies have shown the advantage of approaching science teaching from an inquiry-based method (Handelsman et al., 2004), because it increases students' interest and motivation (Bolte et al., 2012).

> *"Inquiry achieves better understanding of ideas or concepts, and better develops a range of intellectual and practical capacities, but may take more time than traditional methods"* (Gray, 2012, p. 11).

A learning environment is motivating to students

> *"If the learning is connected to positive consequences … e.g. rewards, praise, successful experiments, or leading to an appreciated product by the learning process"* (Bolte et al., 2013, p. 83).

From the enthusiasm that stems from discovery, in the professional development course, of a new way of teaching (Schneider & Bolte, 2012), a search began for an original way to engage students in the teaching of chemistry. The news of a national contest "Adopt Science and Art," with a production of drawings (in our case on cloth), inspired by famous phrases of the world of science's great personalities, was the starting point. It was the perfect opportunity to explore the link between science and art, in an interdisciplinary way, with the aim of promoting curiosity, knowledge and creative skills in students.

Figure 1. The preparation of a yellow color

Figure 2. Staining of tissues with a tea bag

Because the students attended a course on Fashion, we developed a module based on a realistic context, in collaboration with other colleagues. The fruitful collaboration between teachers of different disciplines (scientific-technical and humanistic) has been successfully transferred to the students, who were active protagonists of their knowledge, encouraged by their teachers who carried out the task of facilitating the practical and conceptual work of students. We crossed the boundaries of traditional curricular topics with the goal of enabling students to interact with a more realistic context.

The contribution of the teacher of Italian has been fundamental in the initial and final phases, in which the students freely chose phrases of interest, analyzed the same and finally developed an elaborate commentary to match the graphic work produced. Students worked in heterogeneous pairs, formed so as to enhance individual skills and to encourage cooperation among peers, according to a cooperative learning approach. Teaching with the use of the laboratory was the point of connection between everyday reality and the underlying theory, i.e. going from macro to micro.

The contest 'Adopt Science and Art'

We went from a first experiment in the chemistry laboratory, in which students carried out the extraction of the pigment, chlorophyll, from spinach and used the same as paint on fabrics. In the groups, the work of the students continued so as to find out the best way to join their drawing to what they wanted to express with their commentary. Then the work proceeded with the dyeing and painting, using different plant pigments to allow completion, ending up with the product – a highly original shopping bag which was environmentally friendly.

In Biology lessons, girls observed chloroplasts under a microscope and carried out "in situ" chlorophyll photosynthesis. The Physics teacher addressed the theme of color and light-matter interactions. In Chemistry lessons, students learned the main features of dyes and their chemical composition. In particularly, we paid attention to the colored vegetable substances already known as dyes such as: saffron, indigo, tea and red cabbage.

The students actively participated in the process and positively interacted with what we proposed. Among the many comments and working suggestions of the students, there was one to use coffee to dye some shopping bags. The suggestions proved to be successful, because the colour obtained was really appealing.

In the laboratory of Technologies and Techniques Graphical Representation (TTRG), the girls were engaged in the challenging job of drawing, painting and sewing their shopping bags.

Figure 3. Drawings are designed

Figure 4. The final product: the bags

Figure 5. The bag that won the award

Conclusion

In this learning experience, several aspects deserve to be highlighted.

- *Collaboration between teachers.* The collaboration between teachers of different disciplines is often difficult, because it means to inter-relate many different points of view and to teach in another way. In this experience, we put the meaningful learning of the students prior to our curricula. This work was based

  "on acquiring educational skills involving intellectual, attitudinal, communicative, societal and interdisciplinary learning" (Holbrook & Rannikmäe, 2014, p. 16).

- *Student motivation.* Thanks to the philosophy of the PROFILES project (Bolte et al., 2012), we were able to interest and motivate the students who, in the early days, refused our subjects. What motivated the students was the challenge of competition and their desire to win (Bolte et al., 2013). Thanks to this interest, we were able to teach significant portions of our curriculum and more importantly, learning was fun for the students. Not only was the school attendance high (not a trick that always happens in such schools), but, when it was necessary to finish the job in time, students continued even in the afternoons.
- *Utilizing student ideas.* We have chosen to give maximum freedom to the proposals and ideas of the students and the type of approach has been at least partially seen as 'learning by doing'.

  "If a person can solve a problem by any method, however inefficient or crude, then the correct solution path can be used as a template on which to form new productions, capable of discovering the solution more efficiently" (Anzai & Simon, 1979, pp. 136–137).

  We believe that

  "one swallow does not make a summer, but one swallow does prove the existence of swallows" (Anzai & Simon, 1979).

  With great joy and satisfaction of teachers, students passed the exams with flying colours.

References

Anzai, Y., & Simon, H. A. (1979). The Theory of Learning by Doing. *Psychological Review, 86*(2), 124–140.

Bolte, C., Streller, S., & Hofstein, A. (2013). Motivation and interest. In I. Eilks & A. Hofstein (Eds.), *Teaching Chemistry – A Studybook* (pp. 67–95). Rotterdam, The Netherlands: Sense Publishers.

Bolte, C., Streller, S., Holbrook, J., Rannikmäe, M., Hofstein, A., Mamlok, R., & Rauch, F. (2012). Introduction into the PROFILES Project and its Philosophy. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe. Reflections from the PROFILES Project* (pp. 31–42). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Gray, P. (2012). Inquiry-based Science Education in Europe: Setting the Horizon 2020 Agenda for Educational Research? In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe. Reflections from the PROFILES Project* (pp. 9–13). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Handelsman, J., Ebert-May, D., Beichner, R., Bruns, P., Chang, A., DeHaan, R., Gentile, J., Lauffer, S., Stewart, J., Tilghman, S. M., & Wood, W. B. (2004). Scientific Teaching. *Science, 304*(5670), 521–522.

Holbrook, J., & Rannikmäe, M. (2014). The Philosophy and Approach on which the PROFILES Project is Based. *CEPS Journal, 4*(1), 9–29.

Schneider, V., & Bolte, C. (2012). Professional Development regarding Stages of Concern towards Inquiry-based Science Education. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe. Reflections from the PROFILES Project* (pp. 71–74). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

4.16 Teachers‘ Learning Team as a Tool to Improve Scientific Inquiry Teaching

Jelena Volkinsteine, Dace Namsone & Jazeps Logins – University of Latvia, Latvia

Abstract

In order to help teachers, inexperienced in scientific inquiry teaching, to improve their inquiry teaching, a learning team was set up to undertake action research as a new form of teacher's professional development in Latvia. During one school year, ten secondary school teachers were involved. The gains of the learning team were analysed using recordings of sessions, teachers' prior and final survey and student progress reports. The research showed that their understanding about scientific inquiry and scientific inquiry teaching skills improved as a member of the learning team. The role of the learning team leader was crucial.

Introduction

The implementation of a scientific inquiry philosophy, which formed a component of the FP7 Science in Society project, PROFILES, started in Latvia before PROFILES started. Nevertheless, there was a clear necessity to improve scientific inquiry teaching and learning practice. Learning teams for action research were organised in 2011 by the Center for Science and Mathematics Education for the first time in Latvia. The purpose was to improve teachers' competence to organise and manage a scientific inquiry process in the classroom. The first participants were experienced teachers, with prior experience in teaching scientific inquiry, who very successfully used action research to improve the individual inquiry teaching practice. To continue the develop teachers' professional learning models, within the frame of the PROFILES CPD, a new learning group was set up in September 2012.

Teachers' Continuous Professional Development (CPD) focuses on the teacher as learners (Fullan, 2011), with the teacher as researcher presenting a challenge for the CPD providers to develop new tools for addressing teacher needs. Action research as a method was chosen as it is a deliberate, solution-oriented approach that is group or personally owned and conducted. It is characterized by spiralling cycles of problem identification, systematic data collection, reflection, analysis, data-driven action taken and, finally, problem redefinition. The linking of the terms “action” and “research” highlights the essential features of this method: trying out ideas in practice as a means of increasing knowledge about or improving curriculum, teaching and learning (Kemmis & McTaggart, 1988). The reasons for performing action research fall into the following categories: to promote personal and professional growth, to improve practice to enhance student learning, to advance the teaching profession (Johnson, 1995), to solve a problem, or improve a situation (Taber, 2007).

This paper describes the working experience of the learning team as a tool for improving the practice of scientific inquiry teaching as given in Latvia within the PROFILES project.

Methodology

The research question addressed was – Is a learning team using action research a useful approach to improve individual teacher's scientific inquiry teaching skills?

Ten secondary school teachers (grades 8–12, mainly chemistry) from different schools in Daugavpils city were involved in the group. Good knowledge of chemistry but a lack of classroom experience in scientific inquiry teaching and insufficient experience in analysing and reflecting on their performance, was common for the teachers.

Overall nine sessions were held during the period from September 2012 till June 2013. The learning team sessions were held monthly on Saturdays for 4–5 hours. The sessions were led by a group leader who provided individual feedback to the participants. During breaks between the actual sessions, active communication took place both between the learning team leader and members and among the members themselves. Training within the learning team was held in an informal environment befitting active members of an action research group. The teachers presented their inquiry teaching experience at a PROFILES project conference in May 2013.

The procedure within a learning team session included:

- Teachers' reflection on the action research over the periods between sessions;
- Focused input about the scientific inquiry, or action research practice, according to teachers learning needs;
- Planning on tasks for the next period;
- Reflection about the session.

The data were recorded. The gains of the learning team were analysed using transcripts of the sessions, teachers' prior and final surveys, as well as students' progress reports.

Results

Before engaging in the learning team, teachers evaluated their teaching skills for guiding students' scientific inquiry, as well as undertaking group work and reflection skills (Likert scale used). This first survey pointed out that they were experiencing some difficulties in organizing and managing scientific inquiry experiences for students (see Table 1) and that the teachers were eager to improve them.

Developing tasks or assignments for scientific inquiry and gaining positive indicators of improvement turned out to be the biggest challenge. At the end of the learning team sessions (in May), outcomes from a further teacher self-evaluation varied from 4.3 to 4.9 and had risen by 1.1. to 2 points (see Table 1).

The team leader pointed out the teachers' professional progress. At the beginning of the third session, the teachers were actively asking questions, sharing ideas, helping each other to find solutions. Because the teachers were completely immersed in the problem question, reflection time was extended. At the end, it was great to see how the teachers presented their achievements at the conference.

The teachers assessed student improvement of different scientific inquiry skills during the school year (Likert scale 0–3). The improvement was shown to be 35% to 58%. Teachers mentioned that the students' attitude towards the subject changed – all were working, making efforts, and also actively attending consultations after classes.

At the same time, teachers mentioned gains in their growth of personal and other skills like

"My thinking activated, there were many moments I had never thought about inquiry deeper."

"That is a good experience. I am a practical person by nature. I can implement a ready-made idea. Now I have to generate and analyse the ideas myself."

"In the beginning, I was very inexperienced, because I was not teaching at upper-secondary school and I did not face research much. Now I could include more and in the next year I have planned to continue with other students. I had a great lack of comprehension about its value. Now I have felt good, no doubts, etc."

Discussion and conclusions

Inexperienced teachers improved their scientific inquiry teaching practices in the classroom according to action research undertaken by members of the learning team. This was in line with the hypothesis, irrespective of the fact that teachers initially lacked development of personal performance analyses and reflection skills. The teachers developed these skills over the year as a member of the learning team.

The initial difficulties with developing scientific inquiry related tasks may relate to the fact that teachers usually used tasks or assignments developed by others. The problems regarding obtaining evidence indicative of improvement may

Benefits	Average result on a 5 point Likert scale	
	prior	final
Understanding of scientific inquiry	3.4	4.7
Ability to develop tasks and assignments	2.6	4.3
Ability to manage the students' scientific inquiry during a class	3.2	4.6
Ability to assess the scientific inquiry skills of students	3.4	4.6
Ability to give feedback about the students' inquiry	2.9	4.3
Confidence in organising students' scientific inquiry	3.5	4.6
Personal skills (analysis and reflection)	3.2	4.7
Ability to reflect about team work	3.4	4.9
Ability to obtain indicators of improvements	2.3	4.3
Ability to cooperate in a team	3.4	4.9

Table 1. Teacher benefits from the learning team

be because the teachers have never faced such tasks before. It is interesting to note that in the prior survey, teachers' rated confidence in organising student scientific inquiry higher than their ability on performance. This points to an element of subjectivity in self-evaluation and highlights presence of *'I don't know that I don't know'*.

Improvement of teachers' professional skills may also be related to the role of the team leader. Comparing with another research with experienced teacher groups, the role of team leader was more essential. There was a greater necessity to react to actual teacher learning needs during sessions. More input was given, as well as more time used to discuss. Tasks and assignments were developed through teachers' collaboration and with help from the team leader in the group. The team leader's role in teacher development was crucial, because he/she was the sole expert on scientific inquiry issues within the team and had already had successful experience as a team leader for other groups. This may be the reason for the team leader sometime taking the initiative and guiding the team towards problem solving. In order to achieve this, the learning team leader was required to undertake serious preparation in advance. It was thus seen as important to have special sessions for team leaders in advance.

The creation of learning teams, as a new and successful teacher professional development form in Latvia, needs to be encouraged.

References

Fullan, M. (2011). Innovative teaching and learning research. Findings and Implications. Retrieved from: http://www.itlresearch.com/index.php?option=com_content&view=article&id=40:2011-itl-research-findings-and-implications&catid=10:reports&Itemid=5 (01.07.2014).

Johnson, B. (1995). Why conduct action research? *Teaching and Change, 1*, 90–105.

Kemmis, S., & McTaggart, R. (1988). *The action research planner* (3rd ed.). Victoria, Australia: Deakin University Press.

Taber K. (2007). *Classroom-based research and evidence-based practice*. Los Angeles: Sage.

Picture 1, 2 & 3. Teachers' learning team

4.17 The Effects of Implementing Original PROFILES Modules in Poland

Elwira Samonek-Miciuk & Ryszard Maciek Janiuk – Maria Curie-Skłodowska University, Lublin, Poland

Abstract

One the aims of the PROFILES project is to implement teaching modules which are based on the modifications in science education postulated in the project. The modules were designed based on the principles stated in the project and the curriculum for teaching science subjects in Poland. This article discusses the phases in designing the modules, the conclusions drawn from implementing them at schools and their significance for modernising science education. The discussion is based on two modules: "How does the type of soil influence plant growth?" and "How to use cleaning products in an effective and safe way?"

Introduction

The theoretical framework for science education is extensive and has grown exponentially in the past few decades owing to research conducted in the field (Abell & Lederman, 2007). The framework addresses, among others, such issues as adapting education aims to the needs and capacities of the students, developing their interest in science, using teaching methods which activate students, and integrating knowledge in different science subjects. Recently, the most difficult challenge has been to implement this framework at schools, and in particular to encourage science teachers to introduce changes in the education process. The PROFILES project is one of many initiatives which are designed to help achieve this goal.

Theoretical framework

The implementation of specially designed teaching modules by the teachers participating in the project is important for achieving the goals set by PROFILES (2010). In the first phase of the project, the modules developed as part of PARSEL (2006), a project that had been completed earlier, were used. This made it possible to gain the experience needed to design original modules adapted to the curricula and goals for teaching science subjects in the countries where the teachers participating in the PROFILES project.

According to the core curriculum for general education in Poland (MEN, 2009), the education aims for students taking science subjects include not only acquiring a certain body of knowledge, but also learning how to use the knowledge they have gained in completing tasks and solving problems, as well as developing an attitude that will help them function responsibly and effectively in today's world. Other related skills that students learn include using ICT effectively in order to find and select information, analysing the information critically, and working in a team. These aims can all be achieved by implementing the teaching modules designed based on the principles formulated in the PROFILES project.

Method

The first task when designing the modules was to determine their topics. The author's aim was to select topics that would be related to everyday life so as to motivate students to become actively involved. The authors made sure that the students used the knowledge they had gained earlier in their science classes, and that the new knowledge they would acquire was included in the core curriculum. Another important consideration was the possibility to integrate the knowledge in at least two science subjects. These conditions were met by topics related to soil and cleaning products.

When designing the modules, the authors considered whether the students would be able to do the following:

- pursue questions which they have identified as their own, even if they were introduced by the teacher;
- make predictions based on their emerging ideas about the topic;
- link science knowledge with everyday life and society;
- take part in planning investigations to test their predictions;
- conduct investigations themselves;
- use appropriate sources and methods of collecting data relevant for testing their predictions;
- solve problems or present creative solutions;
- discuss what they find in relation to their initial expectations or predictions;
- draw conclusions and try to explain what they have found;
- compare their findings and conclusions with what others have found and concluded;
- keep notes and records during their work;
- engage in a discussion of the methods used and the results of their investigations;
- tackle real-world questions, issues and controversies;
- collaborate with other students.

It was also decided that the classes would consist of the following stages and student activities, in accordance with the principles of inquiry-based science education (Table 1.).

The module "How does the type of soil influence plant growth?" deals with the structure and properties of soil, and with using it to cultivate plants for consumption. The students become familiar with the factors which influence crop quality. Students taking this module need preliminary knowledge about solutions, acids and bases. The content of the module is discussed from the point of view of soil users, such as pedologists, farmers, owners of allotments, etc. The discussion of the problems is accompanied by numerous practical activities including experiments. These activities, which are designed according to the stages of problem solving learning, allow the students to understand how the soil habitat functions and the problems under discussion. Particular attention is paid to problems related to soil quality and human health.

The second module "How to use cleaning products in an effective and safe way?" provides an opportunity for the students to become familiar with the properties of many substances contained in cleaning products and the way they work, by conducting a series of experiments. Apart from consolidating and supplementing their knowledge of chemistry, the students find out how it can be applied in everyday life. After the lessons the students are able to:

- Find and analyse information about cleaning products available from packagings, journals, books and the Internet.
- Actively participate in the work of a research team.
- Point out the advantages and drawbacks of different types of cleaning products.
- Explain why the proper and safe use of cleaning products depends on one's knowledge about the properties of the

Stage	Student activity
Formulating a focus question	Refer to questioning frameworks
Collecting relevant information	Define, describe, identify, name, list, label
Connecting relevant information	Sequence, classify, compare, explain causes, analyse
Looking in a new way	Generalise, evaluate, predict, justify, synthesise, create, imagine
Sharing new learning	Refer to new research situations and find ways to solve problems

Table 1. Stages of students activities in accordance with the principles of inquiry-based science education

substances contained in them.

- Present and justify their decisions concerning the choice and proper use of cleaning agents.

Findings

When the modules were being implemented, surveys were conducted in order to gather information concerning the teachers' and students' perception of the modules. Some of the results are presented below.

The teachers confirmed that implementing the modules had a positive impact on the students, as had been assumed when designing the modules.

"The students worked actively in groups, especially weak students."

"I could see that the students had a positive attitude towards methods which involved learning by inquiry."

"The students presented the results accurately and shared their observations. They had no difficulty generalising the conclusions drawn based on their observations. They were willing to explore the issues which I had suggested."

There were also remarks concerning some problems which occurred during class.

"Not all of the students know how to present the results of their work orally. More classes similar to these ones, where students can improve their public speaking skills, should be organised."

"Some of the representatives of the groups became more confident in presenting the results of their group work during whole-class discussions."

The vast majority of students also had a highly positive attitude towards the modules.

"The classes were very interesting and well-organised; the friendly atmosphere during the

Teachers' professional competences	Module on soil	Module on cleaning products	Mean X
Motivating students whose level of interest in science is low	3.2	3.4	3.3
Stimulating students' creativity	2.7	2.1	2.6
Developing students' critical thinking skills	1.9	1.5	1.7
Increasing the effectiveness of students' collaboration in teams	3.9	4.2	4.05
Developing students' inquiry skills	4.3	4.1	4.2
Developing students' decision-making skills	4.0	4.5	4.25
Developing students' presentation abilities	3.9	4.2	4.05
Helping students conduct a survey	4.2	4.3	4.25
Using various assessment strategies	3.6	3.3	3.45
Reflecting on the teaching process	2.8	3.2	3.0

Table 2. Level of teachers' professional competences after using the modules

classes made our work more effective."

"It was more interesting to discover knowledge by ourselves than to have it presented by the teacher."

"We all participated actively in the classes and we worked well in groups. I tend to be shy, but I forgot my shyness when we were doing practical exercises."

"In the classroom I felt as if I was a scientist. It must be an interesting job."

"I became aware that many of the things we learn at school can be useful in our daily life."

After the modules had been completed, the teachers filled in a questionnaire. They were to rate the level of their professional competences, which were to develop in the course of preparing for and teaching classes using the modules, on a scale from 1 – minimum to 5 – maximum (Table 2).

Comparing the teachers' professional competences after using the modules with those declared at the beginning of the project (Samonek & Janiuk, 2014), their growth is very visible.

Conclusions

Based on the information gathered, it could be concluded that during the classes taught using the modules, the students used their knowledge of science included in the curriculum and were able to apply it when solving problems, predicting and explaining real-world phenomena, and when carrying out inquiry projects. For instance, they were able to explain what types of scientific models and inquiry processes had been used in carrying out investigations and in reaching conclusions. When problems arose, they were thoughtful in examining their progress and in deciding whether to alter their approach or strategy. The students had a clear overview of their work, its purposes, and how it was related to other ideas or situations, and clearly expressed their ideas to each other or to an audience through speaking, writing and diagrams. The students worked together as a team to make progress. They respected each other's contributions and supported each other's learning. Finally, they divided their work in a fair way and made sure that everyone played an important role in the educational process.

References

Abell, S. K., & Lederman, N. G. (2007). *Handbook of research on science education.* Mahwah, New Jersey: Lawrence Erlbaum Associates Publishers.

PARSEL. (2006). www.parsel.eu.

MEN. (2009). Podstawa programowa z komentarzami. Tom 5. Edukacja przyrodnicza w szkole podstawowej, gimnazjum i liceum - przyroda, geografia, biologia, chemia, fizyka.

PROFILES (2010). www.profiles-project.eu.

Samonek-Miciuk, E., & Janiuk, R. M. (2014). Professional development for science teachers: Experiences and reflections In C. Bolte, J. Holbrook, R. Mamlok-Naaman, & F. Rauch (Eds.), *Science Teachers' Continuous Professional Development in Europe. Case Studies from the PROFILES Project* (pp. 231–241). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

4.18 "Have You Ever Wondered Why Our Clothing Changes Color in the Disco?" A PROFILES Scenario to Contextualizing and Promoting the Study of Introductory Light, Color and Matter

José Gonçalves – Agrupamento de Escolas de Amarante & Universidade do Porto
Pedro Martins – Universidade do Porto & Colégio Ellen Key
Carla Morais, José Barros & João Paiva – Faculdade de Ciências da Universidade do Porto
Nuno Francisco – Universidade do Porto & Colégio Cedros, Colégios Fomento, Portugal

Abstract

The aim of this module is to study the color of light and understand the interaction between colors of light and object's colors. The module was created during a teacher training session, conducted by the University of Porto, during the school year. The module involved a pretest and posttest to figure out student's misconceptions and their evolution after the module's application. The students conducted an investigation on this topic and undertook an experiment to answer their proposed questions. They were involved in an interactive simulation and conducted a color blindness test on the local population.

Introduction

The present module was created during teacher in-service training. It was made with the expertise of the participants and guidance from the trainers and can be viewed on the Portuguese PROFILES website (http://www.profiles.org.pt/wp-content/uploads/2013/10/ModuloCor.zip). The scenario was designed to motivate students in studying introductory light and matter in Physics, at the 8th grade (12–13 years). The science content of the module concerned the concepts of light, color and matter. The module included related activities and was intended to promote education through science, pedagogical approaches including inquiry-based science education (IBSE), the focus of the PROFILES project (PROFILES, 2010).

The module

A motivational scenario was the first step to implement the module (Morais, Paiva & Francisco, 2012). The initial question led to several other questions proposed by the students before implementation, in the second inquiry-based stage, through hands-on experiments and an interactive simulation (provided by PhET website). The simulation can reinforce their conclusions and it can provide a more complete study about light color due to a shortage in colored lamps or even to reduce costs.

Students sought answers to their questions with good results and they discussed justified reasons during a brainstorm. The students' questions also interconnected Physics and Biology.

A strategy at the end of the second stage, which can be used by teachers, is the construction (together with the student's interaction) of conceptual maps to interrelate all the concepts addressed.

For undertaking experimentation, as part of the scientific inquiry, it is important to build a "color box". For this, the following materials are needed: a box, black card paper, red and green cellophane sheets, a lantern, and different objects to place inside the box (Figure 1).

The module also includes as a third stage, student research on color blindness in the local population. They can discuss their results in school or, to local community, for example, in a health center. In this way, the students can be active citizens and they can connect science to everyday life.

At the same time, students can discuss applications in everyday life, like filters for cameras in telescopes, colored photography; how images collected from the HUBBLE telescope are processed to bring colored pictures; and other applications which students can research and bring to class.

Figure 1. The "color box" to be constructed by students

To determine the effectiveness of this module, we conducted both a pre-test and a post-test. Results showed great students' performance related to this topic.

More relevant topics in the test were: explain the color of a cloth corresponding to the reflected color of light (88% of student's answered correctly to this topic with a 64% pre-test–posttest difference); an object's color depends of the incident light (98% of student's answered correctly to this topic with a 61% pre-test–post-test difference); a color's perception depends on the receptors in the eye and their interpretation (90% of student's answered correctly to this topic with a 63% pre-test–post-test difference); yellow light can be obtained from a combination of red and green lights (92% of student's answered correctly to this topic with a 74% pre-test–post-test difference).

The major concern in applying this module is its extension of the national curriculum requirements and a decrease in hours to teach Physics to students at this grade.

We realized, by analysis of the positive students answers and interpellations, that the investigation conducted by students improved their attention and motivation and the test conducted at the end of the unit showed us that the students improved their knowledge in this topic when compared with the pre-test. The test was constructed related to misconceptions in color and light, such as

> *"When white light passes through a coloured filter colour is added to the light"; "The rules for mixing color paints and crayons are the same as the rules for mixing colored lights"; "Colour is a property of an object, and is independent of both the illuminating light and the receiver (eye)"; "White light is colorless and clear, allowing you to see the "true" color of an object."* (Cyberphysics, 2013; Student Misconceptions, s.d).

Conclusion

We conducted a SWOT analysis with teachers related to the module and we considered that:

The strengths of this module were: both interactivity and experimentation; applications into everyday life; easy to construct and low cost materials; easy to use; improves student's motivation.

The weaknesses were: some color failures in PhET's simulation; it takes some time to build the "color box".

The opportunities found were the results presentation about color blindness to a local professional in a Health Center; construct a big "color box" where a student can be placed inside, or to construct "color glasses" where the lens will be a color filter.

Threats found were: the quality of some materials (like cellophane sheets), and reduced time to improve more concepts.

References

Cyberphysics. (2013). Misconceptions: Colour and Vision. Retrieved from: http://www.cyberphysics.co.uk/PGCE/Misconceptions/colour.htm (23.05.2014).

Morais, C., Paiva, J., & Francisco, N. (2012). Módulos inquiry: desenvolvimento e utilização de recursos educativos para a potenciação do inquiry based-learning no ensino da química. *Boletim da Sociedade Portuguesa da Química, 127*, 73–77.

PROFILES. (2010). *FP7 Negotiation Guidance Notes – Coordination and Support Actions – Supporting and coordinating actions on innovative methods in science education: teacher training on inquiry based teaching methods on a large scale in Europe – Annex I – “Description of Work”*, 2010.

Student Misconceptions. Misconceptions. Retrieved from: http://www.darylscience.com/Misconceptions.htm (23.05.2014).

Color Vision (v.1.04), PhET Simulation. Colorado Univeristy. Retrieved from: http://phet.colorado.edu/en/simulation/color-vision (23.05.2014).

4.19 “Green or Mature Wine?” Can We Distinguish Them without Tasting?

Amélia Moutinho, Sílvia Machado & Maria José Pacheco – Agrupamento de Escolas Joaquim de Araújo
Carla Morais, José Barros & João Paiva – Faculdade de Ciências da Universidade do Porto
Nuno Francisco – Universidade do Porto & Colégio Cedros, Colégios Fomento, Portugal

Abstract

The Quinta da Aveleda is located at the heart of the “Vinho Verde” (green wine) demarcated region and is one of the largest wine producers in Portugal. The proximity to the school and the willingness of the company staff made it possible to address a secondary education chemistry topic. Acid-Base Balance/Reaction is selected, among the several possible themes, as the study topic. The tasks performed constituted a great opportunity to recover/consolidate topics studied previously, among others, quantitative composition of solutions and separation processes of mixtures. The cross-cutting theme allowed the development of an interdisciplinary approach involving activities in different areas, such as Biology, Philosophy, History, Geography and the Portuguese Language. Verde/Maduro (green/mature) denominations and demarcated regions have been used as focus for the main question established: “Green or Mature? Can we distinguish them without tasting?” The final output in using this module was a school open day, with the students showing the local community all the materials developed and the conclusions reached.

Motivation: Brainstorming

Although not new for the students, the introduction to an important curricula topic such as this was by using a brainstorming strategy (Figure 1). Many questions were raised but presented are the main filtered ones.

The followed questions were asked: What is green wine (*vinho verde*)? What is mature wine (*vinho maduro*)? Which is the *Vinhos Verdes* region? Is there a *Vinhos maduros* region? How can chemistry help us find answers to the main question?

Figure 1. Poster associated with the module

Webquest: "Soul of Wine"

In this second PROFILES stage of the module, students determine the composition of the wine and attempt to figure out the role of each substance in the quality of the wine. This research study is undertaken by a webquest conducted by the students (organized in groups). In the following the description of the webquest is as presented to the students:

Introduction

From the most ancient times, wine has played a major role in almost all civilizations. "Fruit of the vine and work of man" is not surpassed by any other product of agriculture, combining this tasty fruit and so this nutritional drink privileged with precious nectar, is extracted.

Filled with symbolism, steeped in religion and mysticism, the wine appears very early in our literature, becoming a source of legends and inspired myths.

The terms "gift of the gods", "Blood of Christ", and "essence of life" are attributed to this product confirming the role of wine in the cultural sector and its importance in our civilization.

Wine is a product of high chemical complexity that today is a real challenge for the scientific community, business and consumers. Its constituents are substances that result from the presence of many organic compounds in the grape and their chemical transformations that occur during its production and aging, give the wine qualities. These qualities also depend on the type of wine, the aging time, the vinous grapes which are produced, the manufacturing process and other factors. These qualities – called sensory or organoleptic properties – noticeable focus on three directions:

- The vision, and changes in respect to color, brightness, clarity, transparency, etc.;
- Smell with the aroma;
- The palate, which combines properties as feeling strength flavor, sweetness, dryness, etc.

These different organoleptic characteristics can lead students to propose the classification in green or mature wines. This is very important to a connection made to the region here the grapes came from. There are different demarked areas because different grapes are cultivated there. Another question can arise: "How can we protect our demarked area?". They need to know which state laws can protect this kind of wines' naming region. Another question can help solving this social problem: "Can science solve the ambiguity of these demarked terms – Green or mature, by giving experimental results that can distinguish the different wines?"

The investigation could lead a better understanding of different wines and their connection to a region, in order to increase their production.

Tasks

Students are asked to conduct one investigation related to the subject presented in the introduction. Thus, they can research the composition of the wine, including:

- The main substances of which it is composed;
- The effect that these substances have on the wine's properties;
- Which quality parameters affect wine selection?;
- What distinguishes a green or a mature wine, in particular the role of acidity and alcohol content. *(There needs to be information in the scenario triggering the last aspect).*

Process

The work is undertaken in groups of 3 and presented orally in class in the way considered most relevant. The time period allotted for this task is 15 days (this covers about 4 lab time classes). The oral presentation lasted 12 minutes per group (8 minutes of presentation plus 5 minutes of discussion).

Some resources used by students to consolidate their knowledge about the theme and the above questions are listed below:

http://www.profpc.com.br/Qu%C3%ADmica%20do%20Vinho/Qu%C3%ADmica_vinho.htm

http://www.ajap.pt/sippi/recursos/docs/Vinho.pdfhttp://www.iqsc.usp.br/boletim/Todas-Noticias.php?rowid=130&rowid_vol=17

http://www.ivv.min-agricultura.pt/np4/89

http://www.portalsaofrancisco.com.br/alfa/historia-do-vinho/historia-do-vinho-2.php

http://en.wikipedia.org/wiki/Acids_in_wine

http://www.winecare.com/composition.htm

http://www.calwineries.com/learn/wine-chemistry/wine-acids/tartaric-acid

http://www.vinhoverde.pt/pt/vinhoverde/default.asp

http://danielgoncalvesmaia.blogspot.pt/2007/09/verde-ou-maduro.html

Evaluation

The evaluation of the presentation focused on the aspects listed below:

- The quality and scientific accuracy of the answers to the questions proposed in the brainstorming;
- Quality of the presentation (by the next three steps);
- Analysis, reflections and conclusions of the various members of the group;
- Time management for the presentation;
- At the end, each group undertakes a self-assessment of their work by discussing it with the (a) teacher and (b) colleagues.

Conclusions

This initial task is intended to raise students’ curiosity on the subject of wine in its various forms – cultural, scientific and social.

As a discussion area students can relate to the role of the winemaker and the issues involved and thus, the investigation can now be extended to an actual investigation in the laboratory, making it more complete and exciting.

By now the determination of students’ prior learning about wine and interpreted science topics can lead to developing scientific questions which can be answered by undertaking investigations in the laboratory.

Lab work

The second phase of the work consisted in the determination of parameters that help in the wine type identification, such as the total acidity, pH and alcohol percentage (Figure 2). The obtained results and the extended discussion are used in an attempt to find answers. The total acidity is determined, by titration with a base and expressed, in g/L, as a function of tartaric acid concentration.

$$HOOC{-}CHOH{-}CHOH{-}COOH + 2NaOH \rightarrow Na^{+}{-}OOC{-}CHOH{-}HOH{-}COO{-}Na^{+} + 2H_2O$$

Figure 2. Materials used in the activities

The wines contain different acids, including tartaric, malic, citric and oxalic acid in different concentrations and their ratios depend on several factors, such as soil characteristics, climate and varieties. Tartaric acid is predominant. Tartaric acid (molar weight 150g/mol) is a diprotic acid (containing two hydrogen atoms per molecule that can ionize in water as protons) that can be fully neutralized with sodium hydroxide.

However, the acidity of the wine cannot be determined merely as a function of pH, since this is a complex mixture of various substances such as acids, bases, salts, proteins, among others. Instead, the entire composition is determined in acidic (total acidity) by titration with a base which is expressed as a function of the concentration of tartaric acid in g/L. The total acidity of the wine has values generally between 8.5 and 4g/L, but may however, go up to 15g/L.

The alcohol and acidity are key elements of the wine. Their role is so fundamental that their decision to start the harvest is conditioned by the balance between sugars (which will become alcohol after fermentation) and existing acidity in the grapes.

The acidity is part of the structure of a wine and defines its character, plus longevity. The acidity also embodies the dynamics of a wine in his tasting. A wine with a suitable acidity stimulates salivation and concentration taster. In contrast, a too acidic and sour wine attacks the palate taster, or in a poor wine the acidity becomes heavy and uninteresting in flavor.

Visiting the farm and cellars “Quinta da Aveleda”

Quinta da Aveleda facilities have been visited by the students. In the scope of this guided tour, students had the opportunity to complete their study in the local laboratories. The parameter that effectively allows the wine type distinction (acid ratio) was determined using an infrared spectroscopy (FTIR) technique. Students also had the great chance to discuss with *Quinta da Aveleda* lab staff any doubts they may have had during the entire process.

The visit to the farm now leads to the final part of the module i.e. answering the initial question put forward in the module title. Having acquired the scientific knowledge needed, the discussion can now move to the socio-scientific aspect and students consider whether green and mature wine can be determined without sophisticated equipment such as that at the farm.

SWOT Analysis

This evaluation is presented by topics, which summarize the main aspects developed in this PROFILES module.

Strengths:

- Promoting teaching/learning curricular topics using alternative methodologies and complementary to those provided in the programme;
- Stimulating students’ curiosity for science;
- Developing students’ scientific skills (including labs’ management improvements).

Weaknesses:

- Need of adaptation of the module plan to the action schedule;
- The subject is too broad, making difficult a focus exclusively to the analyzed topic.

Opportunities:

- Allowing the contact of teachers and students with alternative teaching methodologies;
- Give the students the opportunity to contact with local and successful companies;
- Experience exchange between school and local community.

Threats:

- Curriculum limitations
- Time planning including national tests´ evaluation.

Evaluation and outlook

Besides allowing the finding of an answer to the main question, this approach also shows students the scope and applicability of their scientific knowledge acquired during the course. The richness of the studied topic allows the opening of discussions in different areas. The answer to the problem is only possible from a combination of the results of several determinations involving other content beyond Acid-Base topic. Rather than a weakness, this can be seen as an opportunity to broaden the discussion to other programmatic, cultural and social issues, highlighting, at the same time, the importance of integrating different learning areas. Drinking wine in chemistry classes is inappropriate and potentially dangerous. However analyzing it can be an activity which, in addition to being entertaining, is educational. For this reason, the guided tour to the *Quinta da Aveleda* industrial unit is crucial allowing complementation of the study through laboratory tests and interviews/ conversations with experts.

References

Correia, C. (2011). *Espectroscopia de infravermelho na análise de mostos e vinhos. Dissertação de Mestrado em Química Analítica e Qualidade*. Universidade de Aveiro.

Garcia, A.S. (1988). *Controlo de Qualidade dos Vinhos. Química Enológica*: Métodos Analíticos. Instituto da vinha e dos Vinhos.

Navarre, C. (1997). *Enologia. Técnicas de Produção do Vinho*. Publicações Europa-América.

Palma, M., & Barroso, C. (2004). Acid–Base and Precipitation Equilibria in Wine. *Journal of Chemical Education, 81*(1), 94.

4.20 A "PROFILES – Education through Science" CPD Programme – An Example of Good Practice for Science Teacher Continuous Professional Development

Ana-Maria Petrescu, Luminiţa Mihaela Drăghicescu, Laura Monica Gorghiu & Gabriel Gorghiu – Valahia University of Targoviste
Mirela Cristina Negreanu – National Centre for Staff Training in Pre-University Education, Ministry of Education, Romania

Abstract

Generally, at the level of all the educational systems, the problem of teacher training represents a priority, reflected – at projection level –, in a series of educational politics and – at implementation level –, in a variety of programmes of initial and continuous training. At the same time, we observe a continuous preoccupation by European Union states to outline a unitary system of practices, in the field of teacher professional training. Even since 2005, the European Commission elaborated the European Common Principles for Competencies Training and Teachers' Qualification. According to those principles, the didactic profession must imply a continuous professional development, based on permanent formation and information through lifelong learning, to involve mobility both at the level of initial and continuous training, to be based on partnership both in inter-school and trans-school relations, by partnerships concluded with economic agents, with industry, with suppliers of continuous training, etc. In this context, the paper proposes to describe an accreditation process for continuous training programmes in Romania, and to present succinctly, as an example of an exemplary educational practice, the "PROFILES – Education through Sciences" CPD programme.

Introduction

In the context of contemporary society, the teacher must see and act beyond the horizons of the discipline he/she teaches and to build, for students, a set of competencies generally necessary for life. Reported to the multiplying of the roles played by those who embrace a didactic career, reform must be also projected and implemented with appropriate psycho-pedagogical and methodical valences, in the plan of programmes for teacher continuous training.

In Romania, there is a very low percentage of continuous training programmes which are accredited and developed especially for science teachers (for the period 2009–2013). In this context, out of the total of 623 accredited programmes, only 10 targeted especially the training of science teachers (approx. 1.6%). Among those ones, the CPD programme "PROFILES – Education through Science" contributes to an increase of the quality of the continuous training system, implicitly determining an increase in the didactic proficiency, correlated with the necessities of the actual society and with the EU strategy regarding sustainable development. Especially, the professors who teach science disciplines (Chemistry, Physics and Biology), must be endowed with the necessary competencies in order to be able to project and accomplish a didactic demarche, based on valorizing modern didactic strategies, allowing students to be active, to formulate ideas and opinions and to argument and debate over them, to compare these with those of other colleagues, to use their own experiences as a means to access knowledge, to formulate specific competencies for the processing of information, of generating new knowledge and applying this in everyday life contexts. In order to face, successfully, the actual provocations, sciences teachers must learn permanently, must formulate and develop a series of professional competencies, by such means as adequate continuous CPD programmes (Petrescu, Negreanu, Drăghicescu, Gorghiu & Groghiu, 2014).

Theoretical background

In Romania, the continuous training programmes are accredited by the Ministry of National Education through the General Direction Management, Human Resources and National School Network (D.G.M.R.U.R.S.N.). A Specialized Accreditation Commission (C.S.A.), from D.G.M.R.U.R.S.N handles: the continuous training standards for teachers and auxiliary didactic personnel and the various modalities.

The accreditation procedure of a CPD programme is a complex. In the first stage, the CPD provider (an education unit, a non-governmental organization or a juridical, public or private person who – according to the statute – has, as principal activity, the training and professional development of didactic and auxiliary didactic personnel), requests accreditation for a CPD programme.

Requesting the accreditation of the CPD programme, the provider must also prepare documentation indicating evidence of owning or having the usage right for spaces and of the necessary approvals regarding the development of continuous training activities. As an accredited programme, "*PROFILES – Education through Sciences*" followed the entire evaluative demarche. This programme aims to develop professional-didactic competencies regarding inquiry-based science education, valorizing of students' potentialities and individual experiences, by integrating specific themes in the science field and accomplishing of an educational demarche in accordance with the principles of the constructivist paradigm. The subjects included in the training programme were selected on the base of a needs analysis (Gorghiu, Gorghiu & Drăghicescu, 2013). In order to obtain the proposed objectives of the CPD programme, the theoretical activities and practical applications were developed by mixing the traditional format with an ICT learning environment.

The evaluation of the CPD programme consists of two successive stages: discipline evaluation (having the role of progress evaluation), and final evaluation (having the role of summative/balance evaluation) with the purpose of certification. At the discipline evaluation level, each teacher in the PROFILES CPD programme was asked to design a Methodological Guide based on constructivism issues, and a specific Module that proposed a socio-scientific subject based on IBSE methodology, framed in 5 subunits: Introduction, Students' Activities, Teacher's Guide, Evaluation and Teacher's Notes (Gorghiu & Gorghiu, 2014). All developed Units can be found on the national project website: http://www.profiles.ssai.valahia.ro.

Method

In order to analyze the impact of the CPD programme *"PROFILES – Education through Sciences"* at the level of the participants, an investigative demarche was accomplished, based on *focus-group* discussions, covering the objectives of the training programme and how those objectives were to be determined. As such, the demarche took into consideration the opinions of the teachers, referring to the following aspects: the effects of the CPD programme on the development of the professional career, the impact on the didactic strategy, the changes that it generates on approaching specific content from the science area, and the feedback obtained from students who participated in the implementation process.

No.	Indicator	Teachers' feedback
1.	Effects on the professional career development	The CPD programme facilitated: development of the competencies regarding the projection of didactic activities in an integrated manner; exchange of professional experiences with colleagues who teach other disciplines (Physics, Chemistry or Biology), team work (teachers, mentors, experts in psycho-pedagogic disciplines), assuming the role of facilitator in the learning process, formation and development of the competencies for using multimedia techniques in education.
2.	Impact on the didactic strategy	Restructuration of the didactic strategies by valorizing the (inter) active-participative type, which places the accent on: scientific investigation (IBSE), personal and group reflection, experimenting, learning by cooperation/collaboration, learning by problems solving, development of meta-cognitive capacities, development of the individual aptitudes etc.
3.	Changes in the approach of specific contents in Sciences field	Passing from a mono-disciplinary approach of contents to achieving some interdisciplinary connections and to the transfer of knowledge in order to solve everyday problems.
4.	Feedback obtained from students	The students were delighted by the implementation of didactic modules projected in an integrated manner, because in this context, they had the opportunity to approach actual issues, to work in group and to familiarize better with colleagues, to communicate more efficiently with colleagues and teacher, to express and argument the personal opinions about a certain problem/theme, to document and to find new things that otherwise they would never had known.

Table 1. Teachers' feedback related to the PROFILES CPD programme

Findings

The teachers' feedback is systematized in Table 1.

Following participation to the CPD programme *"PROFILES – Education through Sciences"*, the teachers *enriched their professional experience and transferred their theoretical acquisitions in innovative didactic demarches which involve:* implementation in class of didactic strategies, students involvement in learning activities (mostly learning by cooperation), development of students' scientific argumentation abilities, valorizing of knowledge from the science area in everyday life, development of competencies regarding the using of multimedia documents in the educational activities etc. It can be appreciated that the CPD programme was a successful one and it can be expressed that, in the future, such training programmes will have a higher representativeness at national and even international levels.

Acknowledgements

This publication reflects the views only of the author, and the Commission cannot be held responsible for any use, which may be made of the information contained therein.

References

Gorghiu, G., & Gorghiu, L. M. (2014). Analysing the Relationship between the Effectiveness of the PROFILES Continuing Professional Development Programme and the Dissemination/Networking Process. In C. Bolte, J. Holbrook, A. Hofstein, & F. Rauch (Eds.), *Science Teachers' Continuous Professional Development in Europe: Case Studies from the PROFILES Project* (pp. 267–277). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Gorghiu, G., Gorghiu, L. M., & Drăghicescu, L. M. (2013). Consulting the Educational Actors – What Do Romanian Science Teachers Really Need? *Procedia – Social and Behavioral Sciences, 83*, 528–534.

Petrescu, A. M., Negreanu, M. C., Drăghicescu, L. M., Gorghiu, G., & Gorghiu, L. M. (2014). Innovative Aspects of the PROFILES Professional Development Programme Dedicated to Science Teachers. Paper presented at 6th World Conference on Educational Sciences (WCES 2014), Valletta, Malta.

*** O.M. 5564/7.10.2011 concerning the approval of the Methodology for periodical accreditation and evaluation of the continuous training providers and of the training programmes proposed by them.

*** Romanian Law of Education, no.1/2011.

4.21 Results of Classroom Implementation of Modules Developed for Use in Romanian Pre-primary and Primary Education

Ana-Maria Suduc, Mihai Bîzoi, Gabriel Gorghiu & Laura Monica Gorghiu – Valahia University of Targoviste, Romania

Abstract

The Romanian primary and pre-school teachers, especially because they are working with young children showed, on many occasions, interest and openness to new approaches and teaching techniques which are aimed to increase students motivation and involvement in learning activities. Although PROFILES project aims to promote Inquiry-based Science Education (IBSE), the project activities focused more on secondary education and less on primary one, and, even less, for pre-school education. The results of PROFILES-derived modules implementation in three pre-school groups and 10 primary classes, in Romania, illustrate that the use of IBSE at those levels might be a right choice. The paper presents specific data related to classroom implementations of non-PROFILES teachers (who didn't participate in the PROFILES CPD programme) at pre-school and primary classrooms and related to the students and teachers feedback.

Introduction

Researchers and teachers consider Inquiry-based Science Education (IBSE) to be stimulating for students' motivation, students' application of research skills, construction of meaning and acquiring scientific knowledge (Alake-Tuenter, et al., 2012). In IBSE approaches, the learning is done not by direct teaching, but by gaining a way of understanding and solving a real everyday problem, developing skills to act in a given situation, according to information previously held or acquired intentionally by students to solve the situation. Starting with the pre-school and primary school age, the children are very curious for solving everyday life problems in this case IBSE seems to be a proper approach for science teaching at these levels (Gorghiu, Gorghiu & Draghicescu, 2013).

Method and results

Participants

In March 2014, the Romanian PROFILES team organised different dissemination activities of the PROFILES Modules (produced by Romanian teachers who graduated the "PROFILES – Education through Science" CPD programme) at primary and pre-school levels. As a result of those actions, six pre-school and 12 primary education teachers expressed their interest to learn more about IBSE, selecting and then implementing a suitable modified PROFILES module. Therefore, between April 7 to 11, 2014, these modules, modified to suit the age and mental development of the students, were implemented in 3 pre-school groups and 10 primary classes. The implementation activities were particularly organized in this period of time, for the freedom given to the teachers by the National Programme *'A different School – To know more, to be better.'* This National Programme consists of a yearly organization for one week, of non-formal activities, in each educational institution, in the second semester.

Because PROFILES modules were designed by secondary education teachers, the pre-school and primary teachers didn't have a large selection base. Therefore, the primary and pre-school teachers chose modules which focused on problems appropriate to the children age, and in addition, they adapted those modules, by changing the vocabulary, activities, evaluation strategies, etc. At pre-school level, the teachers changed the original modules so much that it can be considered they created new modules, starting from the idea of the original modules. Table 1 presents the name of the original modules which were selected, adapted and implemented by the primary and pre-school teachers, but also the number of classrooms where those modules were implemented.

In the implementation process, 18 teachers were involved (six pre-school and 12 primary education teachers) and 244 children (50 pre-school and 194 primary students) at all class levels, except the small group, at pre-school level. Table 2 presents the distribution of children and classes per class level.

Of the 18 participating teachers, three had less than 10 years' experience in education, 11 had between 11 and 20 years of experience, and four had more than 21 years.

Teachers' feedback

After the implementation process, the teachers were asked to fill in a feedback questionnaire. The questionnaire contained three structured questions and four open questions. The teachers' responses show that they gave great importance to IBSE and an integrated approach to science. All the teachers consider as very important the implementation of an IBSE strategy for science learning. Asked to elaborate on their answers, the teachers indicated different advantages of an IBSE strategy, like: *"the students make their own connections between theory and practice of current problems"*, *"it promotes cooperation and direct interaction"*, *"real examples motivate students"*, etc.

To the question related to the need for an integrated approach to the sciences (Chemistry, Physics and Biology), on a scale from 1 – *to a great extent* to 5 – to a very little extent, it is not surprising that 69% of the teachers responded 1 and 31%, 2.

It is important to note that all the teachers took progress to be the impact on students of the implemented activities, related to: (a) students' interest in science lessons, (b) formative effects on students, (c) activeness of students, (d) group cohesion and (e) school performance.

Asked to give their impression about the implementation of suitable PROFILES modified modules, the teachers gave positive feedback such: "*(...) we succeeded to engage students to investigate, not only at school, but also, at home (...)", "(...) the idea of this project is innovative and even necessary in an era when information comes more from TV and the Internet, than by direct contact"*, etc.

Children's feedback

The feedback from primary and pre-school students was collected in three questionnaires used also for collecting the feedback of the students of the involved teachers. Depending on their age and reading skills, the questionnaires were filled in: (1) by the students (grades I–IV) – one copy of each questionnaire for each student and (2) by the teachers (at pre-school groups and grade 0),

Education level	Original Modules Names	No. of implementations (classrooms)
Pre-school	Water – The substance of life	1
	Water and life	2
Primary	Water and life	2
	"Healthy eating" or "Fast-food eating"?	2
	Let's eat healthy!	2
	Are we what we eat? The daily menu choice	4

Table 1. Modules selected for modification by the primary and pre-school teachers

	Class level	No. of classrooms	Children
Pre-school	Middle group (4–5 years)	2	28
	Big group (5–6 years)	1	22
Primary education	Class 0 (6–7 years)	1	22
	Class I	3	60
	Class II	2	32
	Class III	2	39
	Class IV	2	41
Total		**13**	**244**

Table 2. Distribution of children and classes per class level

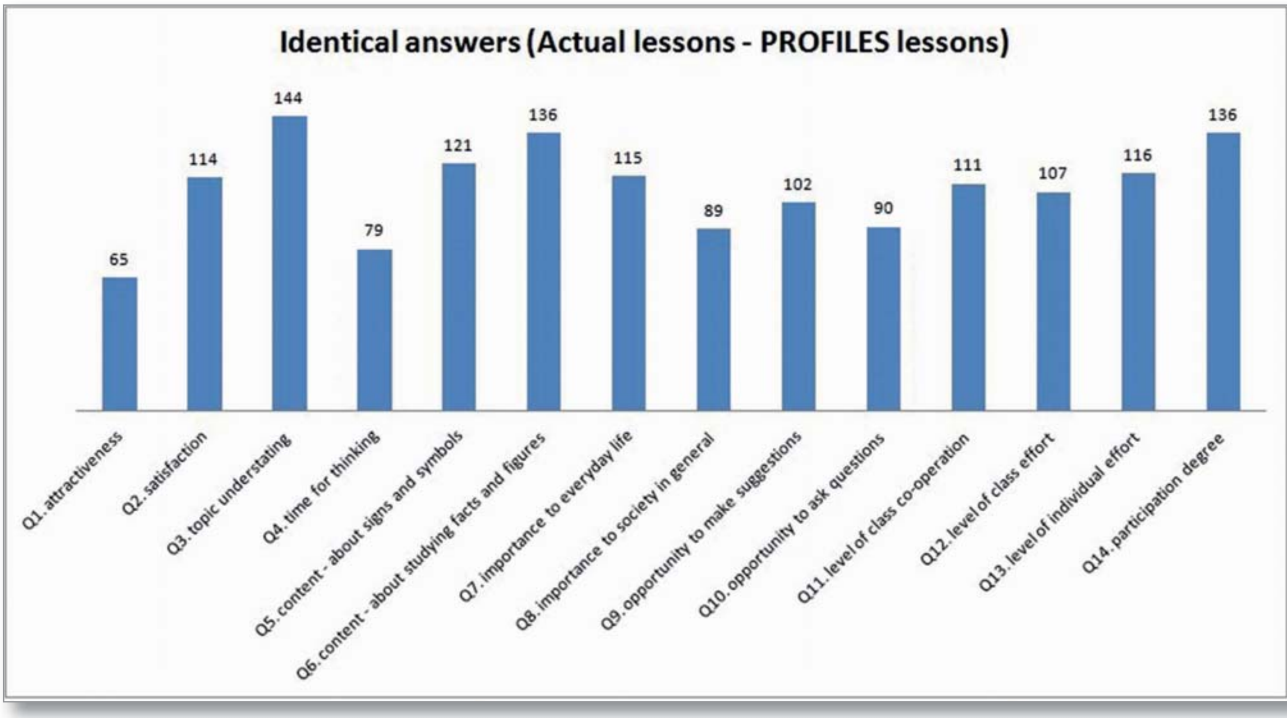


Figure 1. Number of students who gave identical responses in both questionnaires: regarding actual Science lessons and these lessons adapted from PROFILES modules

depending of the students' attitude, responses, involvement and different evaluation tools.

The feedback questionnaire aimed to evaluate: 1) the children's view on *actual* and *real* science lessons (Questionnaire A), 2) the children's view on *ideal* science lessons which they would like to attend (Questionnaire B) and 3) the children's view on these science lessons (which is Questionnaire A applied only for the lessons using the carefully modified PROFILES modules).

Both *Questionnaires*, A and B, contain questions/ statements about science lessons related to: attractiveness (Q1.), satisfaction (Q2.), topic understating (Q3.), time for thinking (Q4.), content – about signs and symbols (Q5.), content – about studying facts and figures (Q6.), importance to everyday life (Q7.), importance to society in general (Q8.), opportunity to make suggestions (Q9.), opportunity to ask questions (Q10.), level of class co-operation (Q11.), level of class effort (Q12.), level of individual effort (Q13.) and participation degree (Q14.).

Figure 1 shows how many students gave similar responses for each question, in both questionnaires: the one related to the actual, real science lessons and the one about these science lessons. From the total of 244 children who participated to the study, 144 (59%) found these science lessons as attractive as usual science lessons; 136 (56%) students felt involved in these science lessons as much as in usual science lessons; 121 students considered that the modified PROFILES-derived science lessons are about studying facts and figures, respectively about signs and symbols, in the same degree as in usual science lessons.

The analysis of the initial and post implementation questionnaires shows that the students found the lessons using PROFILES modified modules better than usual ones, from different aspects. For example, 19% more students considered these lessons as being *extremely enjoyable* as compared to the usual science lessons (21% considered the usual science lessons as being *extremely enjoyable*, and 40% considered the PROFILES-derived science lessons *extremely enjoyable*); 10%, and 16%, respectively, were *extremely contented*, or *very contented* with the PROFILES-derived lessons, compared to the usual science lessons; 6% more children said they always understood the topic of these lessons compared with usual science lessons; 20% more students had always time to think about the questions asked; 17% more students consider the topics of the PROFILES-derived science lessons as being *extremely important* to society in general; 14% more children had the opportunity to make suggestions to the teacher; 13% more children considered the class being *extremely cooperative* compared with usual science lessons; the students effort was *extremely large* for 13% more children.

Conclusions

The implementation of the carefully implemented, PROFILES-modified modules in the three pre-school groups and 10 primary classes, in Romania, was a real success, as shown by the feedback received both from teachers and students. Overall, the modified 'PROFILES' science lessons proved to be more enjoyable and relevant, from different aspects, for young students than usual science lessons.

Acknowledgements

This publication reflects the views only of the author, and the Commission cannot be held responsible for any use, which may be made of the information contained therein.

References

Alake-Tuenter, E., Biemans, H. J., Tobi, H., Wals, A. E., Oosterheert, I., & Mulder, M. (2012). Inquiry-Based Science Education Competencies of Primary School Teachers: A literature study and critical review of the American National Science Education Standards. *International Journal of Science Education, 34*(17), 2609–2640.

Gorghiu, G., Gorghiu, L. M., & Draghicescu, M. I. (2013). Consulting the Educational Actors – What Do Romanian Science Teachers Really Need? *Procedia – Social and Behavioral Sciences, 83*, 528–534.

4.22 Three Years of PROFILES Experience in SLOVENIA: Networking, Teacher Professional Development and Student Gains

Mira Metljak, Saša A. Glažar, Mojca Juriševič, Jerneja Pavlin, Miha Slapničar, Janez Vogrinc & Iztok Devetak – University of Ljubljana, Faculty of Education, Slovenia

Abstract

The European project PROFILES is designed by professional development and network activities to give teachers knowledge of the PROFILES approach of science teaching for enhancing students' scientific literacy and motivation to learn science. Three main objectives of the Slovenian PROFILES project are seen as: (1) teacher professional development, (2) networking activities and (3) students' gains regarding motivation and knowledge. These are presented and evaluated after three years of project duration. All together 121 in-service and pre-service teachers were included into the PROFILES network in this three years. The programme of teacher professional development was well accepted and participants mainly found all activities (lectures, workshops, group work, class work,…) as an asset to their further work. Also some evidence of teacher ownership can be detected. Regarding students gains in knowledge and motivation, there are some significant differences between the experimental and control group, but further analyses are needed. The main objections of teachers were directed towards administrational work and incompatibility of the approach with the Slovenian school system which are the issues that will need to be addressed in the future.

Introduction

After one year of preparation and three years of activities performed in the context of the PROFILES project, now close to ending, we believe there are many reasons to evaluate the three main objectives that were at the forefront of the project in Slovenia: (1) teacher professional development, (2) networking activities and (3) students' gains regarding motivation and knowledge. The development of the three selected components is also important with regard to the PROFILES project desired outcomes and in wishing to disseminate the philosophy of the project as wide as possible and to influence the motivation of students for science education and science professions. All three components were monitored and data collected in different ways. In this paper we present just the main conclusions of the three year's work with teachers and consequently students of 13 and 14 years of age.

Theoretical framework

PROFILES is an European project devised to give teachers, through professional development and networking activities, ownership and knowledge of the PROFILES approach for the teaching of science subjects so as to enhance the scientific and technological literacy of students (Rauch & Dulle, 2012). This is through learning environments that

> *"embrace students' intrinsic motivation to learn science and enhance their competence in understanding scientific inquiry and socio-scientific decision-making"* (Holbrook & Devetak, 2014, p. 5).

To address the objectives of the project, teacher professional development programmes were organised, a network of collaboration established and implementation of the innovation was conducted in class.

The idea of teacher cooperation as a supporting mechanism in teacher professional development and consequently better school performance is not new (e.g. Lieberman, 2000; Rhodes & Beneiske, 2002). Cooperation in networks is an effective way to exchange ideas and information in the common field of interest (Rauch & Dulle, 2012) and in the matter of individual needs of members (Lieberman, 2000). In teacher networks also, a social dimension is usually present and normally they are organised for a definite time for the need to achieve a certain goal and/or cooperate so as to follow similar guidelines. The feeling of mutual respect and exchange/transfer of knowledge, know-how, leads to a professional development of the members (Gatt & Costa, 2009).

In the Slovenian PROFILES project, all activities in the teacher professional development (TPD) programme were conducted in the frame of action research, recognised as one of the important factors in TPD, in particular when designed as a collaborative process involving teachers and researchers. It was presumed that Slovenian science teachers would benefit most from the TPD, if they would be actively engaged in their professional development. Specific teacher training and implementation of the modules were considered as cycles in the action research model (Devetak & Vogrinc, 2014).

The PROFILES approach focuses on students' motivation to learn science, as mentioned above. Moreover, from this point of view in the PROFILES approach, both extrinsic motivation oriented (e.g. extrinsic rewards mostly by means of teacher' motivational feedback) as well as intrinsic motivation oriented (e.g. interest in science, meaningfulness of learning, academic self-concept) are important, but the latter is highlighted (Devetak, Vogrinc & Glažar, 2011; Bolte et al., 2011; Bolte & Holbrook, 2012). This leads to the conclusion that, in a concrete learning community, as a PROFILES learning context actually is, students gradually develop their own social-participatory learning role, depending on their own perception of individual features of the existing learning context. In addition, for raising students' interest in science learning, the development of their science competences is also important. Science competences comprise the in-depth understanding of science concepts, being able to conduct research, understanding the nature of science and being able to analyse and evaluate information from everyday live science, etc. (Glažar & Devetak, 2013).

Figure 1. Leaflet as an invitation to joining the project

Purpose and aims

The purpose of the paper is to present the development of the Slovenian PROFILES project through three years of work and the outcomes in teacher ownership and student gains.

The basic aims are:

- to present teachers' activities in adopting IBSE with the 3-stage PROFILES model;
- to illustrate how students accept IBSE as seen from the teachers' point of view;
- to show some evidence how the innovation enhance students' motivation to learn science;
- to discuss the differences between the control and experimental group of students in their knowledge achievements.

Findings

Organising and spreading the PROFILES teacher network

The networking and TPD within the context of the PROFILES project started in Slovenia after one year by a national team of consultants in 2011/2012 school year. After sending an invitational leaflet (Figure 1) to all primary and secondary schools, 45 teachers from 35 schools decided to participate and were divided into smaller groups of 2 to 5 teachers regarding their professional science orientation (biology, chemistry, physics, general science) and teaching level (primary or secondary school); to each group one of six consultants was appointed. Teachers and consultants worked in teams to develop an innovating teaching approach following the PROFILES framework. In the first year, 34 teachers concluded the training by active cooperation at meetings and workshops, gathering and reporting data, giving feedback in a reflection questionnaire and self-monitoring of their progress and engagement with a portfolio.

Second year teachers, in the 2012/2013 school year TPD programme, primarily responded to the invitation of the existing PROFILES network teachers (10 teachers), 10 were the members of the first year and the rest of all together 33 teachers (from 27 different schools) responded to the leaflet that was once more sent to all schools. Also this year members were divided into groups and besides the consultant, also one member of the previous year was appointed to the group as a leading teacher.

In the third year, only teachers that cooperated in the first or second year were invited to participate. 12 teachers responded and decided to participate in one or more of the third year TPD activities: (1) upgrading and revising the existing modules, (2) implementing modules, (3) helping prepare the Slovenian PROFILES book, and (4) organising regional workshops about PROFILES.

In the second and third year also, 54 pre-service students decided to join an elective course, where the PROFILES approach was presented and modules were developed throughout the semester. A more detail structure of the member network is presented in Table 1.

Teacher professional development

The TPD PROFILES programme comprised three major activities: (1) lectures, (2) modules development, and (3) implementation of modules. All three activities were extensively supported by group-consultant communication, between teacher communication and analyses of implementation as to upgrade teachers' knowledge and professional development.

The content of the lectures were mainly prepared on the basis of teacher wishes and a needs questionnaire, completed by the involved teachers.

Subject	School level	School year 2011/2012	2012/2013	2013/2014	Total
Biology	Primary	9	5	3	17
	Secondary	/	1	/	1
Chemistry	Primary	25	13	8	46
	Secondary	5	1	/	6
Physics	Primary	4	9	1	14
	Secondary	2	/	/	2
General science	Primary	/	4	/	5
Pre-service primary school teachers (general science, chemistry, environmental education)		/	11	43	54
Total		**45**	**43**	**55**	**143**

Table 1. Number of in-service and pre-service teachers included in the PROFILES network separately for each school year by professional science orientation and teaching level

Lectures by the consultant team, given throughout the year within six whole group meetings, were undertaken considering the following content: PROFILES philosophy and 3-stage modelling presentation; learning with experimenting; PARSEL and VAUK PROFILES organisation of the modules presentation; scientific literacy and pseudoscience; portfolio; action research; motivation for learning science; instruments, gathering and organising data for students' achievement analyses to measure the implementation gains; and SWOT analyses. The second part of the meetings was meant for the module development by separate groups, organised as workshops.

Drafts were prepared according to the learning content to be developed into a 3-stage PROFILES module and according to the further upgrade by the Slovenian project team for students' independent group work (active learning). After the meeting, groups individually decided how the module will be further developed. Usually members of the group divided the work and whole groups' revision was made when the module was drawn together. The leading teacher of each group had an important role in coordinating all the work. Finally, the module was revised by the consultant and implemented in class. After implementation data was collected and experiences in the group, with analyses, were exchanged and discussed with the consultant. The phase of implementation and gathering data about students' achievements and motivation and teachers' observations can be understood as a form of practitioner research that can also be identified as action research (see Figure 2).

In their reflection reports, almost all teachers stated that they would use modules also in the future and that they would recommend the modules to their peer-teachers. Many of them recognised the

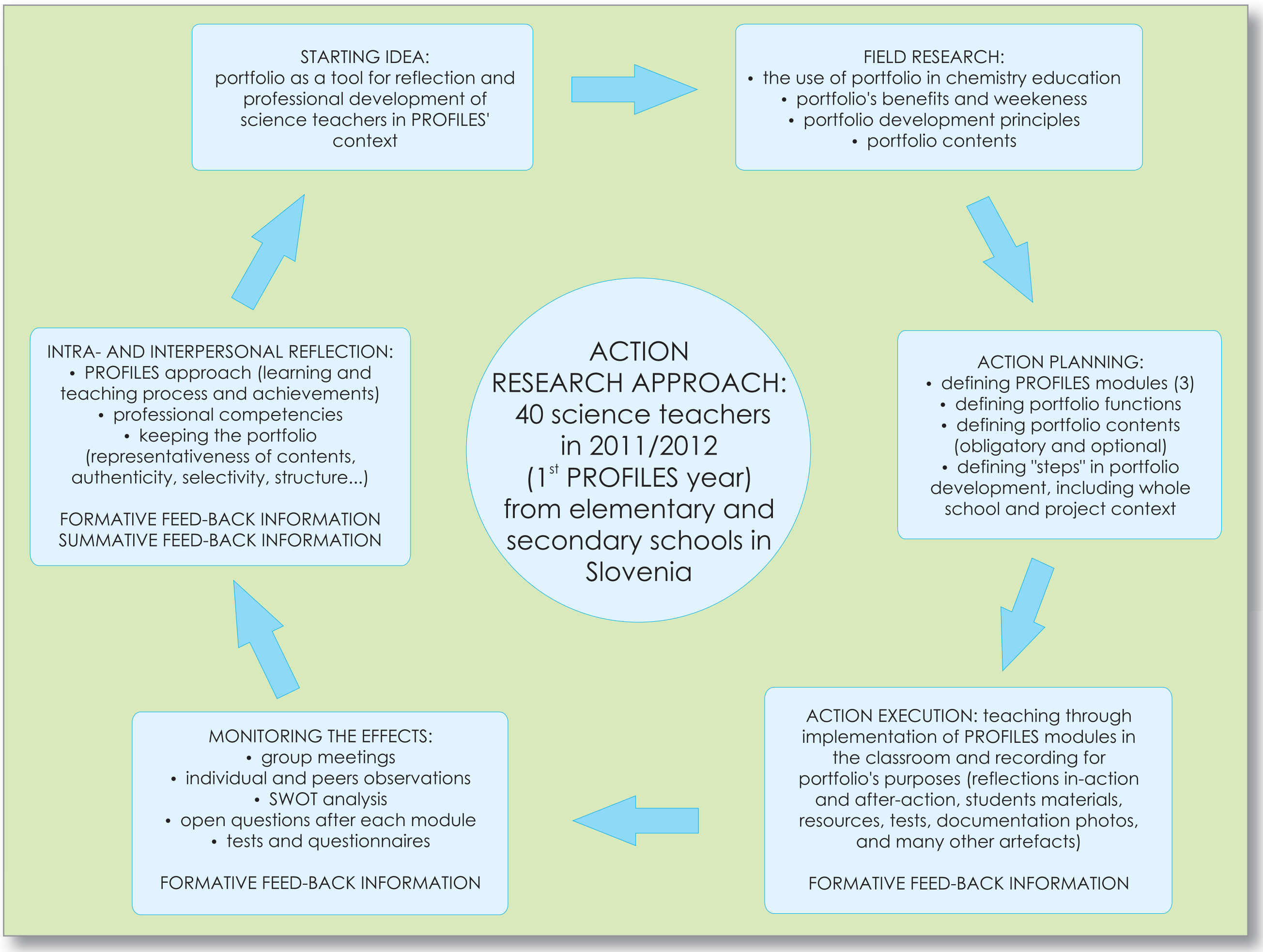


Figure 2. A model of CPD programme implemented in the PROFILES framework in Slovenia in the first and second round of the project (Juriševič, Devetak & Vogrinc, 2012).

PROFILES TPD as important to their professional development in gaining new knowledge and new experience. They liked working in groups. The negative responses usually referred to the fact that modules are, regarding the Slovenian school system, too time consuming, that there was much work to be done in gathering and organising data and some of them stated that a lack instructions from the consultants was present.

Networking and dissemination activities

Besides meetings and workshops, other network activities were provided to members to enhance the ownership and TPD experience, e.g. Slovenian PROFILES web page, translated newsletters, conferences, mutual internet services of exchanging material (Dropbox), e-mail lists, leaflet, e-mailing, publishing,… and were important for further network spreading.

As we have already mentioned, the last years' activities included teacher organization of PROFILES workshops for their peers in local/regional community. Till now, two workshops have been organised and 18 teachers have been informed of the PROFILES philosophy of the 3-stage module structure and on project experiences (see Table 2). Also members of the national team are present at workshops so as to present the philosophy of the project and the project TPD programme. PROFILES teachers also gave some important information on their experiences regarding the project and as one teacher put it: *"I found my cooperation in the project as very meaningful, since professional development is an important part of my work; it is important not to get stuck in a routine."*

Some teachers also stated, in their reflection reports, that they have already presented the project in their schools at educational conferences and to subject groups that are organised in regions at national level.

The last activity of the teachers' action research process is a publication of the research results. Some teachers and their consultants participated in the first PROFILES conference with a poster presentation in Berlin (Šket, Petrica Ponikvar, Klopčič, Mesojedec & Ferk Savec, 2012) and also at a national science and mathematics teachers' conferences, where they disseminated their work among other non-PROFILES teachers through oral presentations and workshops (i.e. Šket, Ferk Savec & Devetak, 2012; Devetak & Ferk Savec, 2013; Devetak, 2014), as well as poster presentations.

We have already pointed out that Slovenian teachers found the PROFILES approach and the active learning of students, as was the Slovenian specific design in module development, a great contribution to gifted education. That's why the PROFILES team decided to co-organise, with the Centre for Research and Promotion of Giftedness at the Faculty of Education University of Ljubljana, a national conference for teachers and other interested participants, entitled 'Motivating Gifted Students for Learning Science (2013)'. More than a hundred participants were introduced to the PROFILES project, its approach and 3-stage model by the key-note speaker, Dr. Jack Holbrook (Visiting Professor at Centre for Science Education, University of Tartu, Estonia plus the ICASE representative in the PROFILES project and Dr. Iztok Devetak, the Slovenian PROFILES team leader).

Organised at school	Region of participants	Number of teachers
Primary school of Trbovlje	Dolenjska	8
Primary school of Črni Vrh nad Idrijo	Notranjska and Primorska	10
Primary school of Marezige	Primorska	To be organised
Primary school Koseze	Ljubljana region	To be organised

Table 2. PROFILES Workshops in Slovenia

Also seven posters, presenting PROFILES project activities, were presented by PROFILES teachers to those teachers who are not involved directly in PROFILES. In the afternoon, one of the seven workshops was directly connected to PROFILES: PROFILES principles as a motivational aspect for the gifted for learning science; but also other workshops provided participants with new knowledge and methods for motivating gifted students for science learning in primary and secondary school, also one of the project goals.

In the last year, teachers are involved in preparing material for a publication on PROFILES; also developed modules are to be included. The book, with a teachers' guide, is to be disseminated to all primary and secondary schools in Slovenia. A further contribution to the PROFILES dissemination is a special issue of the CEPS journal published by Faculty of Education, University of Ljubljana. In this special issue, five PROFILES related papers are published from four different partner countries. Papers range from general description of the PROFILES philosophy on which learning modules are based, to specific applications of PROFILES teaching and learning approach in Finland, Germany, and Sweden.

Module implementation and results of data analyses

Almost all included teachers implemented at least two of three modules, developed in the group. Before and after each implemented module, a learning environment questionnaire and knowledge test was given to students of the experimental and also control classes. In the first year, 989 elementary school (grades 8 and 9) students participated in the study. Students were assigned into experimental (PROFILES modules) (N=570; 57.6%) and control groups (exposed to traditional teaching) (N=419; 42.4%). In the second year, more than 1 000 students of experimental or control groups were involved in the project, but until now data are received from only 503 students (285 (54,5%) students for the experimental group and 218 (41,7%) students from the control group).

Comparative results from the first year showed that different components of the learning environment perceived by students' before and after the implementation of PROFILES modules have not changed significantly except relevance of the topics – the importance of science topics perceived by students for their everyday live and for the society in general ($t=-2.550$; $df=208$; $p=0.11$). Results also showed that PROFILES students perceived the learning environment for learning biology, chemistry and physics significantly different than their non-PROFILES counterparts; (i.e. Satisfaction - students' interest in science lessons and how happy they feel in science class ($t=2.782$; $df=340$; $p=0.006$) and Subject orientation – how science teaching is organized; teacher using mostly symbolic representations, graphs for teaching mostly facts ex-cathedra ($t=3.241$; $df=340$; $p=0.001$) mean values were higher for the PROFILES groups).

Significant differences were shown in favour of the experimental group regarding knowledge assessment in four sub-sample groups of different subjects. But, inexplicably, in one sub-sample group, Chemistry 2, the average results of the control group were higher than that of the experimental group. Further analyses of the subsample groups were needed since, as we have seen, significant changes of knowledge were on the subsample level. Also analyses regarding the differences between teachers that were in the project for the first year, or have been involved also in the first year, were needed since some evidence showed that long term TPD led to better results.

First analyses of the second year data on knowledge assessment showed no significant differences between experimental and control groups. Also no changes in motivation were noted.

In their reflections, teachers mostly answered that students corresponded positively and with interest to the implemented innovation, that they gained knowledge of the content and also knowledge on experimenting. But they also point out that there were differences between students – some behaved more as observers while others played a more active role. Nevertheless, there was common agreement between teachers in Slovenia that the PROFILES approach was profitable for all students with the most profitable being the gifted students.

Conclusion and Prospects

Lieberman (2000) points out that the building of mutual trust, to which collaborative relationships contributes significantly is essential for the development of new ideas. Allowing members to participate in the creation and maintenance of the group activities, so as to progress their professional identity, interests and learning, is extremely important. These aspects are in accordance with the implementation of PROFILES philosophy in the science classroom. To implement PROFILES in teacher pre-service education and professional development is also important and this is a subsequent, main objective of the project PROFILES, so that we can apply new approaches in teaching and learning science at primary, secondary and tertiary levels of education. Following these approaches, the importance of students' motivation to learn science must receive emphasis, because it is essential in promoting and developing students' scientific literacy, enabling their effective participation in modern society as adult citizens.

References

Bolte, C., & Holbrook, J. (2012). An Introduction to PROFILES: Professional Reflection-Oriented Focus on Inquiry based Learning and Education through Science PROFILES. In L. Campanella (Ed.), *Book of Abstracts from ICCE/ECRICE 2011* (p. 53), Rome, Italy. Retrieved from: http://www.iccecrice2012.org/_downloads/416-Inglese-abstract-book.pdf (22.07.2013).

Bolte, C., Streller, S., Holbrook, J., Rannikmäe, M., Mamlok-Naaman, R., Hofstein, A., & Rauch, F. (2011). PROFILES – Professional Reflection-Oriented Focus on Inquiry-Based Learning and Education through Science. *Proceedings of the European Science Educational Research Association (ESERA)*. Lyon, France.

Devetak, I. & Ferk Savec, V., (2013). Evaluating the effectiveness of students' active learning in chemistry. In A. Isman (Ed.), *4th International conference on New horizons in education, Procedia – Social and behavioral sciences*, Amsterdam: Elsevier, 106, 1113–1121.

Devetak, I., (2014). Učenje kemije z raziskovanjem v družbeno-naravoslovnem kontekstu izobraževalnega pristopa PROFILES. In M. Metljak (Ed.), *Sodobni pedagoški izzivi v teoriji in praksi: zbornik povzetkov* (p. 93). Ljubljana: Pedagoška fakulteta.

Devetak, I., & Vogrinc, J. (2014). The Slovenian PROFILES model of science teachers' professional development. *PROFILES newsletter, (5)*, 9–13. Retrieved from: http://www.profiles-project.eu/res/Newsletters/PROFILES-Newsletter-5.pdf?1391067866 (05.06.2014).

Devetak, I., Vogrinc, J., & Glažar, S. A. (2011). Guided Active Learning in Chemistry Modules used in the PROFILES Project in Slovenia. In *Book of Abstracts from ESERA 2010,* 255, Lyon, France.

Gatt, S., & Costa, M. F. P. C. M. (2009). Networking school teachers to promote better practice in the teaching of science across Europe. *European journal of education, 44*(4), 493–506.

Glažar, S. A., & Devetak, I. (2013). Pouk naravoslovja in naravoslovna pismenost [Science teaching and scientific literacy]. *Didactica Slovenica, 28*, 53–66.

Holbrook, J., & Devetak, I. (2014). Editorial. *Center for educational policy studies journal, 4*(1), 5–8.

Juriševič, M., Devetak, I., & Vogrinc, J. (2012). Teacher's Portfolio in the PROFILES Context: Some Conceptual and Methodological Issues. In L. Campanella (Ed.), *Stimulating reflection and catalysing change in chemical education: Book of Abstracts from ICCE/ECRICE 2011* (p. 494), Rome, Italy. Retrieved from: http://www.iccecrice2012.org/_downloads/416-Inglese-abstract-book.pdf (05.07.2014).

Lieberman, A. (2000). Networks as learning communities: shaping the future of teacher development. *Journal of teacher education, 51*(3), 221–227.

Motiviranje nadarjenih učencev za učenje naravoslovja: zbornik povzetkov [Motivating Gifted Students for Learning Science: book of abstracts] (2013). Ljubljana: Pedagoška fakulteta Univerze v Ljubljani. Retrieved from: http://www.pef.uni-lj.si/fileadmin/Datoteke/CRSN/Posvet2013/naravoslovci/Zbornik_abstraktov.pdf (05.06.2014).

Rauch, F., & Dulle, M. (2012). How to involve steakholders in IBSE networking. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based science education in Europe: reflections from the PROFILES project* (pp. 59–67). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Rhodes, C., & Beneicke, S. (2002). Coaching, mentoring and peer-networking: challenges for the management of teacher professional development in schools. *Journal of in-service education, 28*(2), 297–310.

Šket, B., Ferk Savec, V., & Devetak, I. (2012). Pouk kemije z uporabo učnih modulov PROFILES. In M. Vidmar & A. Avsec, (Eds.), *Zbornik prispevkov* (pp. 96–97). Nacionalna konferenca Poti do kakovostnega znanja naravoslovja in matematike, Brdo pri Kranju, 11. in 12. decembra 2012. Ljubljana: Ministrstvo RS za izobraževanje, znanost, kulturo in šport.

Šket, B., Petrica Ponikvar, P., Klopčič, S., Mesojedec, D., & Ferk Savec, V. (2012). Experiences of a group of Slovenian teachers in the development and implementation of PROFILES modules. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 148–150). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

4.23 Implementation of IBSE Strategies in Training Teachers for Health Education

Esther Charro, Elena Charro, Susana Plaza & Ángela Gómez-Niño – School of Education, University of Valladolid, Spain

Introduction

Several studies have shown the convenience of approaching science teaching from an inquiry-based approach, because it increases students´ interest and attainments levels and stimulates both, students and teachers motivations (National Academy of Sciences, 1996). This change in science teaching, from mainly deductive to inquiry-based methods, impacts directly on teachers, key players in science teaching renewal. Teacher's abilities, self-efficacy and ownership in the implementation of new methods of teaching and their motivation and collaborative reflection with other teachers are essential elements for the success of any science education renewal (Rocard et al., 2007). Moreover, some authors consider that such shifts must be extended to University teachers in charge of training future teachers (Eugenio, Charro & Gómez-Niño, 2012).

Because of the need and importance of quality training, one of the areas susceptible to using inquiry is higher education. Since inquiry activities have great training power, the development of future primary teachers is, specifically, an ideal space for it (Kenny, 2010).

The European project, PROFILES (*Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science*) (Bolte et al., 2011), promotes IBSE (Inquiry-based Science Education) through raising the self-efficacy of science teachers to take ownership of more effective ways of teaching students, supported by stakeholders. The proposal innovation is developed through working with 'teacher partnerships' to implement existing, exemplary context-led, IBSE focussed, science teaching materials enhanced by inspired, teacher relevant, training and intervention programmes. This is undertaken by reflection, interactions and seeking to meaningfully raise teacher skills in developing creative, scientific problem-solving and socio-scientific decision-making abilities in students. The measures of success are through (a) determining the self-efficacy of science teachers in developing self-satisfying science teaching methods, and (b) in the attitudes of students toward this more student-involved approach. The project focuses on "open inquiry approaches" as a major teaching target and pays much attention to both intrinsic and extrinsic motivation of students in the learning of science. The intended outcome is school science teaching becoming more meaningful, related to 21st century science and incorporating interdisciplinary socio-scientific issues and IBSE-related teaching, taking particular note of gender factors (PROFILES, 2010).

While it is true that the application of PARSEL (Bolte et al., 2009) modules are designed primarily to students at the secondary school level, the method based on inquiry science learning makes them potential tools for use in other areas and educational spaces (Bolte et al., 2011). In this way it can generate new and innovative learning processes in all educational levels.

In this work, we present data related to how a PARSEL type module has been developed, which involved inquiry strategies in the field of health education.

Description and development

A novel experience is presented of applying PARSEL type teaching-learning materials with students undertaking a Degree (in Primary Teacher Education) in the School of Education of the University of Valladolid (Spain). In particular, a new module is proposed as an adaptation of two developed in an earlier project (PARSEL, 2008). The new PROFILES module, entitled *"The alcohol we could drink for driving safely"* is used to promote responsibility in our students. Students are asked to plan an investigation in order to identify which are alcoholic drinks with the highest alcohol concentration, to discover how much alcohol can be drunk and the time necessary for waiting to avoid driving with a BAC level above the legal limit. The competences involved are: investigative skills, cooperative-working skills, conceptual development and communication skills. The curriculum content is related to Biology, Chemistry, and, in particular, to Mathematics. The students work on modeling alcohol metabolism/degradation and their capacity of undertaking a prediction about how much alcohol they can drink and for how long they have to be waiting before considered as being able to drive safely.

In advanced, students were given the criteria that would be later used to assess their performance in such competences, which included: correct use of concepts, comprehension of STS-E associations, information selection, critical analysis, conclusions quality, and presentation and discussion of the conclusions. We carried out participant observation, and a questionnaire was also directed to students. The application of the module was satisfactory, since it allowed the development of the above-mentioned competences, and moreover promoted a very "natural" revision or extension of curricular content. It is noteworthy that the construction of a reflexive and critical attitude, in relation to the ethical and moral consequences of the scientific and technological development, was the competence evaluated the lowest overall. At the end, students related the data collected from their search and investigation (observations in the lab and several calculations) so as to give an informed opinion on the issue, i.e. socio-scientific decision-making (Fortus, Krajcik, Dershimer, Marx & Mamlok-Naaman, 2005; Bond-Robinson, 2005).

The above findings support the need for developing activities in which such competences are promoted also in University students. Within this intended outcome, and by means of the training/intervention linked to stakeholder support, a key target is to convince teachers that methods they have studied and tried can and will strongly improve the quality of their own science teaching (Michelsen & Lindner, 2007).

References

Bolte, C., Streller, S., & Erb, M. (in press). PARSEL Goes to School – From Pre-service Teacher Training Courses to School Science Projects. In C. Bolte, J. Holbrook, & W. Gräber (Eds.), *Making science lessons popular and relevant – Examples of good practice*. Book of invited presentations at the International PARSEL Conference 2009, in Berlin. Münster: Waxmann Verlag.

Bolte C., Streller S., Holbrook J., Rannikmäe M., Mamlok-Naaman, R., Hofstein A., & Rauch F. (2011). *PROFILES – professional reflection-oriented focus on inquiry-based learning and education through science*. Proceedings of an International conference, ESERA.

Bond-Robinson, J. (2005). Identifying Pedagogical Content Knowledge (PCK) in the Chemistry Laboratory. *Chemistry Education Research and Practice, 6,* N2, 83–103.

Eugenio, M., Charro, E., & Gómez-Niño, A. (2012). *Extending Inquiry-based science education to teacher training through the PROFILES Project: An experience*. Proceedings of 1st International PROFILES Conference. Berlin, Germany.

Fortus, D., Krajcik, J., Dershimer, R., Marx, R., & Mamlok-Naaman, R. (2005). Design Based Science and Real-World Problem-Solving. *International Journal of Science Education, 27*, N 7, 855–879.

Michelsen, C., & Lindner, M. (2007). Science Teachers' Professional Development in new Programs in Germany and Denmark. In *ESERA 2007, European Science Education Research Association, International Conference in Malmö, August 21–25, 2007* (p. 55). Malmö: ESERA.

Kenny, J. (2010). Preparing Pre-Service. Primary Teachers to Teach Primary Science: A partnership-based approach. *International Journal of Science Education, 32*(10), 1267–1288.

Rocard, M., Csermely, P., Jorde, D., Lenzen, D., Walwerg-Henriksson, H., & Hemmo, V. (2007). *Science Education Now: A Renewed Pedagogy for the Future of Europe*. Brussels: European-Commission.

4.24 Promotion and Evaluation of the Development of Students' Competences by Using a PROFILES Module, Based on the Analysis of STS News

Marcia Eugenio – School of Education, University of Valladolid
Mary C. Izquierdo – Institute of Secondary Education (IES) Politécnico
Elena Charro – Faculty of Education and Social Work, University of Valladolid, Spain

Introduction

A module developed by Galvão, Reis, Freire and Oliveira (2006), consisting of an analysis of newspaper/magazine news about socio-scientific issues, had been previously applied by the authors with students on the Degree programme in Teacher Training at the University of Valladolid (Uva, Spain) (Eugenio & Charro, 2012). Such a module promoted an inquiry-based strategy in science education, and was particularly useful in the frame of a specific part of a compulsory subject devoted to Science, Technology, and Society, since it allowed satisfactory work on the specified curricular content of such a subject, as defined in Uva (2010).

Following our perspective of approaching science education from an inquiry-based strategy so as to enhance the level of interest, raise the level of achievement of students, and also to promote the usefulness of the module, we used it again in the Secondary Education programme. In this case, the news module was selected based on its contents, in order to match with several topics that are treated in the subject "Biology and Geology", for which our focus this time was evaluating whether the implementation of the module allowed the development of competences initially defined. With that purpose, students were asked to complete a survey and whose results are presented here.

Presenting the PARSEL module

The module "Analysis of newspaper/magazine news about socio-scientific issues" (Galvão et al., 2006) is based on the use of spreading publications dealing with science and technology to facilitate the comprehension by students of the tensions occurring among science, technology, society and the environment, and to offer the chance to treat socio-environmental conflicts in a practical and applied manner during lectures. The inquiry-based strategy that is promoted by this module constitutes the central axis of the European project, PROFILES.

The module was designed to improve the following students' competences:

1. development of substantive knowledge, since the student has to identify scientific and technological knowledge conveyed by the news;
2. development of epistemological knowledge, since the student has to discuss issues related to the environment and to argue about the potentialities, as well as limitations, of the scientific enterprise and its relationship to technology, society and the environment;
3. development of reasoning competences, since the student has to select information, analyze and interpret it and argue his/her ideas with others;
4. development of communication competences, since the student has to present and discuss his/her ideas to the others;
5. construction of a reflexive and critical attitude in relation to the ethical and moral consequences of the scientific and technological development.

The criteria that would be later used to assess students' performance were specified by the module and given to them in advanced. Such criteria included: correct use of concepts, comprehension of the STS-E relations, information selection, critical analysis, quality of the conclusions, and presentation and discussion of the conclusions.

Describing the experience

This experience took place in the frame of the subject "Biology and Geology", which is optional for students in the so-called E.S.O. course, the first stage of Secondary Education in Spain. This first stage consisted of four courses (students are between 12 and 16 years old) and was followed by a second stage formed of two courses (students between 16 and 18 years old), at the end of which students needed to pass a general exam in order to obtain a Diploma and be able to access the University. Thus, both the subject and the course constituted an adequate frame for applying the module. The total number of students was 35, and corresponded to two different groups.

The professor asked students to look for and gather news related to science, technology, society, and the environment, in relation to three main topics: genetic engineering, evolution, and ecology, constrained by two main conditions: such news dealt with current issues, and was closely related to the content previously studied in the subject. Contrary to the manner in which planning of a module was undertaken, students worked alone to read, look for information for comprehension of the topic, summarized and critically reflected on a particular piece of selected news, which was afterwards exposed and discussed with the rest of their classmates. They were also required to write all this information (basically a summary, with additional information and critical comment) and to hand it to the professor. The process took place throughout the whole course in 2013/2014, in such a way that a small part of the class every time was dedicated to the analysis of STS news.

Do you agree in relation to the following assertions related to the activity of analysing STS news?

		Degree of Agreement			
		Strongly Disagree	Disagree	Agree	Strongly Agree
1.	This activity has been interesting				
2.	This activity has been enjoyable				
3.	This activity has allowed me to get into the breaking news in science and technology				
4.	This activity has allowed me to get acquainted with reading news about science				
5.	I think that this activity has stimulated my reflexive and critical capability				
6.	I consider that through this activity I have developed my communicative skills				
7.	This activity has promoted discussion among classmates				
8.	Now I am more capable of identifying the social and environmental controversy that a certain scientific-technological progress involves				
9.	I think that, from now on, I will pay more attention to news dealing with science and technology				
10.	I think that, from now on, I will pay more attention to social an environmental implications of a certain scientific-technological progress				
11.	I will try to follow the breaking news of some topics that we have treated during lectures				
12.	Now I am more interested in science and technology than before the activity				
13.	Now I know better what is currently being done in science and technology than before				
14.	Now I feel more capable of reading about science and technology				
15.	Now I am more aware of the ethical and moral consequences of the scientific and technological development				

Table 1. Survey designed to analyse students' perception on the achievement of general objectives and improvement of student competences using the module devised by Galvão et al. (2006), based on the analysis of STS news. All assertions were written in a positive sense.

%	Strongly Disagree	Disagree	Agree	Strongly Agree	Sum of Disagreements	Sum of Agreements	Difference (Agreement-Disagreement)
A1	0,0	14,3	62,9	22,9	14,3	85,7	71,4
A2	5,7	57,1	28,6	8,6	62,9	37,1	-25,7
A3	0,0	0,0	60,0	40,0	0,0	100,0	100,0
A4	2,9	45,7	40,0	11,4	48,6	51,4	2,9
A5	8,6	37,1	54,3	0,0	45,7	54,3	8,6
A6	2,9	22,9	54,3	20,0	25,7	74,3	48,6
A7	40,0	34,3	11,4	14,3	74,3	25,7	-48,6
A8	8,6	25,7	48,6	17,1	34,3	65,7	31,4
A9	11,4	42,9	34,3	11,4	54,3	45,7	-8,6
A10	8,6	31,4	51,4	8,6	40,0	60,0	20,0
A11	14,3	54,3	28,6	2,9	68,6	31,4	-37,1
A12	11,4	25,7	45,7	17,1	37,1	62,9	25,7
A13	0,0	14,3	42,9	42,9	14,3	85,7	71,4
A14	2,9	37,1	51,4	8,6	40,0	60,0	20,0
A15	8,6	25,7	48,6	17,1	34,3	65,7	31,4

Table 2. Percentages of answers to every assertion in every category of agreement and disagreement

Describing the survey

The survey was Likert type, and consisted of 15 assertions mostly related to the initially defined objectives for the activity. Students were asked their degree of agreement, as differentiated in four levels (Table 1). By following the general recommended rules when designing a survey, the same kind of information was requested by means of different questions, in order to test for consistency in students' responses (e.g. questions 3 and 13, 4 and 14, or 8 and 15). Moreover, some questions were included in order to test for the achievement of general objectives applicable for current science education, in general, and for inquiry-based science education, in particular. Examples are teaching science to generate a general culture, connecting science to everyday life, making it more enjoyable for students, and improving students' motivation in relation with science and technology (Acevedo, 2004; Vilches & Gil-Perez, 2007).

Results

Results were as shown in Table 2. Since all assertations were written in a positive sense, agreement always corresponded to high and positive values in the columns named as "Sum of Agreements" and "Difference (Agreement-Disagreement)", respectively.

The highest percentage of agreement was observed in relation to A3 (100%); all students considered that the activity was useful to find out the current issues of science and technology. Moreover, very high percentages of students (over 85%) agreed with assertions A13 (same as A3) and A1, thus stating that the activity was interesting to them. Lastly, between 60% and 75 % of students agreed to assertions A8, A15, A12, A10, and A14 (A8 and A15 being also covered) and reflected the global objective of the activity: *"facilitating the comprehension of the tensions occurring among science, technology, society and the environment"*. Assertions A10 and A14 were related to objective (2) development of epistemological knowledge and (3) development of reasoning competences, respectively. Finally, assertion A12 focused on improvement of students' motivation in relation to science and technology, which occurred in 63% of students.

The highest percentage of disagreement was observed in relation to A7 (74%), an assertion related to the objective (4) development of communication competences. This can be attributed both to the fact that students worked on the module on news individually and not by groups, as originally proposed in the module, and to the fact that discussions after the expositions were commonly poor, as pointed by the professor. However, the same percentage of students agreed with assertion A6, also related to the same objective; students considered that the activity was useful to develop their communicative skills, in this case likely in relation to the need for preparing an exposition. Also, the percentage of disagreement exceeded that of agreement in relation to assertions A11 and A2; most students found that the activity was not enjoyable (around 63%), and stated that they will not try to follow the current issues of science and technology that have been treated in the class (around 70%).

Conclusion

Based on students' degree of agreement to the set of assertions that were formulated to test mainly for the usefulness of the PARSEL module developed by Galvão et al. (2006), we can conclude that:

1. The general objective of *"facilitating the comprehension of the tensions occurring among science, technology, society and the environment"* was achieved.
2. The activity was considered interesting, but not enjoyable.
3. The activity was, in general, considered useful for the purpose of finding out the current issues in science and technology, and most students (63%) declared to be now more interested in science and technology, but at the same time stated that they will not try to follow the breaking news.

Overall, a general objective of current science education, such as teaching science as culture, was achieved (Acevedo, 2004).

References

Acevedo, J. A. (2004). Reflexiones sobre las finalidades de la enseñanza de las ciencias. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias, 1*(1), 3–16.

Eugenio, M., Charro, E., & Gómez-Niño, A. (2012). Extending Inquiry-based Science Education to Teacher Training through the PROFILES Project: An Experience. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 151–152). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Galvão, C., Reis, P., Freire, A., & Oliveira, T. (2006). Avaliação de competências em ciências: Sugestões para professores do ensino básico e do ensino secundário. [Competence evaluation in science. Suggestions for basic and secondary education teachers]. Lisboa: ASA.

Uva (Universidad de Valladolid). (2010). Memoria de Grado en Educación Primaria por la Universidad de Valladolid. Retrieved from: http://www.uva.es/export/sites/default/contenidos/gobiernoUVA/Vicerrectorados/bak/VicerectoradoCalidadInnovacion/Grado/CCSS/UVaGradoEducacionPrimaria.pdf (19.05.2014).

Vilches, A., & Gil-Perez, D. (2007). La necesaria renovación de la formación del profesorado para una educación científica de calidad. *Tecné, Episteme y Didacxis, 22*, 67–85.

4.25 PROFILES: Developing a Continuous Professional Development Programme to Enhance Inquiry-based Science Teaching

Torodd Lunde & Shu-Nu Chang Rundgren – Department of Engineering and Chemical Sciences, Karlstad University, Sweden

Abstract

In this paper, based on PROFILES, a continuous professional development (CPD) programme, developed in Karlstad Sweden, is presented. A main strategy is to incorporate the elements of (1) the existing laboratory teaching tradition, and (2) the teachers' group reflections on inquiry-based science teaching, mentioned in the Swedish curriculum (Lgr 11), besides offering possibilities to use new equipment and using the PROFILES 3-stage teaching modules as teaching support. This is to facilitate the teachers' negotiation process between the key ideas of laboratory work existing in the Swedish teaching tradition/teaching practice and laboratory inquiry-based teaching discussed in the international literature. The CPD programme demonstrates the co-constructing process among the in-service science teachers and the CPD provider. The participants are 15 lower secondary teachers in a programme lasting for forty hours, distributed as six workshops.

Letting teachers negotiate meaning within a co-construction process

New ideas are never implemented in a vacuum, but rather in a compact body of an existing teaching practice. It is important to recognize that practice is part of larger cultural and historical contexts (Engeström, 1999). If the on-going practice is seen as meaningful by the participants it becomes a focus for negotiating new meaning (Wenger, 1998), in which a practice can therefore be conserved within a community despites external changes and becomes a long-lived tradition, more or less resistance to changes. Furthermore, traditions are typically unarticulated and taken for granted, as well as selective, when new ideas are adopted (Williams, 1973). The key ideas of new things are absorbed into the existing tradition, or transformed into more of what already exists by the participants holding unarticulated and unchallenged assumptions about the key ideas. Therefore, it is fruitful for in-service teacher training programmes to take the cultural and historical teaching tradition into account, when implementing new ideas.

There is a long tradition of laboratory work in science education, and according to the above-mentioned claim by Williams (1973), this can influence teachers' responses to external changes in aims, content and teaching methods. In later Swedish science curricula (Skolverket, 2000; 2011), inquiry-based science activities are emphasised as a mean to develop students' critical thinking when they e.g. examine information or arguments founded on scientific knowledge claims. In contrast to these curricula, several Swedish studies have mapped the existing laboratory teaching tradition in compulsory school science and disclosed that cook-book laboratory activities and/or the emphasis on conceptual learning are dominating (e.g. Högström, Ottander & Benckert, 2006). In addition, Högström et al. (2006) revealed that science teachers are not aware of scientific methods and nature of science as learning outcomes. Despite this, Gyllenpalm, Wickman and Holmgren (2010) disclose that there exists a strong tradition of practical activities that resemble inquiry, as conceptualized in the science education literature, but at the same time, lacking essential elements. Accordingly, it is revealed that there exists a conflation of inquiry as a learning outcome with a teaching method (Gyllenpalm et al., 2010). This indicates a striking disharmony between the curricula and teaching practice. How to bridge this gap to achieve harmony is important for science educators today, which is in line with the intentions of the PROFILES project.

A fruitful way to bridge the gap is to take central aspects of the tradition into account as an important variable. Continuous professional development (CPD) programmes allow teachers to participate in a co-constructing process, emphasizing school culture and teachers' voices as a central part (Harrison, Hofstein, Eylon & Simon, 2008). It also enables possibilities to challenge and negotiate the meaning of the key ideas within the traditions and teaching practices. Therefore, in this study, reflections on the explicit aspects of teaching traditions, in relation to inquiry, are used as a means to promote negotiation of meaning during the co-constructing process of designing a PROFILES module. Besides, the opportunity of using new equipment was offered to give teachers the possibility to work with a new artefact, which was not embedded in the teaching tradition in the co-constructing process. Therefore, in the design of the CPD programme, the different aspects of the tradition, linked to laboratory work are illuminated and made explicit, and the potential tensions with inquiry-based science teaching are discussed.

Designing a continuous professional development (CPD) programme by taking teaching tradition into account

A CPD programme, within the framework of an EU FP7 project, PROFILES, was developed. A 3-stage model (contextualization, de-contextualization/ inquiry-based activity and re-contextualization/ argumentation) used within PROFILES, was shared in the CPD with 15 in-service teachers. The CPD programme lasted for forty hours in total, distributed on four whole days and two half days, within a school year. Fifteen lower secondary teachers within the same school district participated and were divided into five groups with three teachers in the group discussion section in the CPD. Each group was expected to develop, implement and present their own developed PROFILES module. During the co-constructing process, the aspects of the teaching tradition were made explicitly in the lectures and the teaching material on which teachers were asked to reflect was offered to the teachers. The design of the CPD programme was as shown in Table 1.

Summary

During the PROFILES CPD programme, the participating teachers were given time and space to reflect on their own teaching tradition and the key ideas shown in the Swedish curriculum concerning inquiry-based science teaching.

Sessions (Total 40 hours)	Agenda	Group activity
Session 1 8 hours	*Presentation on importance and framework:* External lecturer presents an historical overview of the growth of scientific literacy (SL) in science education and on the importance of scientific literacy for citizenship. The teachers are introduced to socio-scientific issues (SSI), context-based teaching and IBST by the facilitator. All of this is linked to the aims in existing curricula. Introduction of the PROFILES 3-stage module as a framework to design context- and inquiry-based science teaching sequences. The teachers participate in a context- and inquiry-based science teaching PROFILES module. Aims, content and methods in the science teaching tradition versus curricula is discussed in light of the module and aims in curricula.	• Teachers divided in groups by themselves • Group reflections • Choose theme for the module
Session 2 8 hours	*Pedagogical content knowledge (PCK):* Facilitator present content- and pedagogical content knowledge liked to IBST. External lecturer presents PCK linked to SSI and context-based teaching. Laboratory work in traditional teaching is contrasted with IBST.	• Group reflections • Start to create a 3-stage module
Session 3 8 hours	PCK: Facilitator presents PCK linked to assessment when carrying out IBST. Assessment of laboratory work in traditional teaching contrasted to what ought to be assessed according to the curricula.	• Time to continue the planning of a 3-stage module
Session 4 8 hours	Group activities (only)	• Time to fulfil the planning of a 3-stage module • Teachers expected to implement module after this session
Session 5 4 hours	Group activities (only)	• Reflections on implementation • Fulfill documentation of the module
Session 6 4 hours	Presentations of modules	• Presenting modules, experiences and reflections on implementation • Sharing documented modules

Table 1. The CPD programme developed in this study and the related data resources

From our findings, it was disclosed that, to a high extent, the participating teachers explicitly addressed the differences in seeing inquiry as a learning outcome versus a teaching method (Gyllenpalm et al., 2010), but not by every participating teacher though.

The results showed that (1) the design of our CPD programme, by taking teachers' teaching tradition into account and making this explicit for in-service teachers so as to reflect and discuss, was feasible; (2) it takes time to negotiate the traditional and new ideas to achieve harmony. Our CPD programme is presented as a good model for more and long-term CPD programmes to promote inquiry-based science teaching.

References

Engeström, Y. (1999). Activity theory and individual and social transformation. *Perspectives on activity theory,* 19–38.)

Gyllenpalm, J., Wickman, P. O., & Holmgren, S. O. (2010). Secondary science teachers' selective traditions and examples of inquiry-oriented approaches. *NorDiNa (Nordic Studies in Science Education), 6*(1), 44–60.

Harrison, C., Hofstein, A., Eylon, B., & Simon, S. (2008). Evidence-based professional development of science teachers in two countries. *International Journal of Science Education, 30*(5), 577–591.

Högström, P., Ottander, C., & Benckert, S. (2006). Lärares mål med laborativt arbete: Utveckla förståelse och intresse. *NorDiNa (Nordic Studies in Science Education), 5*, 54–66.

Skolverket. (2000). *Grundskolan – kursplaner och betygskriterier 2000*. Stockholm: Skolverket.

Skolverket. (2011). *Curriculum for the compulsory school, preschool class and the leisure-time centre 2011*. Stockholm: Skolverket.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge, UK: Cambridge University Press.

Williams, R. (1973). Base and superstructure in marxist cultural theory. *New Left Review, 82*, 3–16.

4.26 Student Responses to a PROFILES 3-stage Teaching Module

Susanne Walan – Department of Environmental and Life Sciences, Karlstad University
Shu-Nu Chang Rundgren – Department of Engineering and Chemical Sciences, Karlstad University, Sweden

Abstract

In Sweden, like in other developed countries around the world, there is a problem with young people's low interest in the sciences. To solve this problem, research indicates that inquiry- and context-based science education (IC-BaSE) can increase students' interests in learning sciences. During the past years, the European Commission has also pointed out that there is a need for change in teaching science subjects and the focus needs to move towards IC-BaSE. In addition to the low interest in learning the sciences, recently, the Swedish results, in PISA 2012, have also shown a lower performance among all the other OECD participating countries. Therefore, it is time and necessary for science educators to work to enhance students' learning interests and their engagement with the sciences in Sweden. This study, based on the EU FP7 project, PROFILES, develops an IC-BaSE, PROFILES 3-stage teaching module (the theme was Crime Scene Investigation, CSI) and to investigate students' responses to this module. A Likert scale questionnaire is revised and developed based on the PROFILES MoLE questionnaire to collect student responses. A total of 105 15-year-old students have participated in our study. The results show that the students are positive to the PROFILES 3-stage module. The implications to science teaching and learning are discussed.

Introduction

After the PISA 2012 report, released in December 2013 (Swedish National Agency for Education, 2013), the Swedish students' poor performance has drawn different stakeholders' responses in Sweden. Some have argued that PISA test items were not developed for measuring the 'right' thing, but a distinguished science education researcher from Australia, Peter Fensham, has pointed out that PISA instruments in years 2000, 2003 and 2006, all consisted of units made up of real world contexts involving science (Fensham, 2009). This has suggested that items shown in PISA studies could assess students' abilities of transferring their knowledge from school science to an everyday context, i.e. interacting with socio-scientific issues, such as genetically modified food, abilities which have been linked to the important ultimate goal of science education, scientific literacy. In this case, based on the Swedish students' poor performance in PISA 2012, it could be considered time and taken as necessary for science educators in Sweden to work on enhance students' learning in the sciences.

To promote students' learning interests and engagement in the sciences, the European Commission (e.g. EC, 2007) recommended that inquiry- and context-based science education (IC-BaSE) is necessary as a step towards teaching that aims to promote scientific literate citizens. Numerous EU projects are working on IC-BaSE. PROFILES (Grant no. 266589) is one of these projects and serves as a foundation of this study (Bolte, Holbrook & Rauch, 2012). An important question is – What is IC-BaSE teaching? Firstly, we can consider it from the separate ideas coming from the inquiry-based and context-based teaching approaches. Yeomans (2011) suggests inquiry-based teaching can be defined as students' learning, which takes place through inquiry (skills employed by scientists) in a meaningful context. The skills include raising questions, developing methods, collecting data, reviewing evidence, discussing results and drawing conclusions. Bennett and Holman (2002) indicate that developers of context-based courses wish to impact on students' affective responses to the sciences. Context-based courses are existing since the 1980s (Bennett, et al., 2007), however, there is no explicit link between the above-mentioned context-based courses and inquiry activities and it is difficult to measure the learning outcome (Bennett & Holman, 2002). Mainly, a context-based approach increases students' learning interests in the sciences. But still, inquiry is seen internationally as an important aspect in scientific literacy and the context-based approach is to motivate students' learning in the sciences. Therefore, IC-BaSE is

Stage	Activity	Time (in hours)
1. Contextualization	The context of the crime scene is introduced via TV news presented locally. A section of a police report is given to the students presenting more information about the case.	0.5
2. De-contextualization	The inquiry step includes preparation of DNA samples which already have been through PCR. The samples are dyed and applied on gels for electrophoresis. When the electrophoresis has finished running, the gels are developed and samples are analyzed.	2
3. Re-contextualization	The students discuss the results and draw conclusions based on the evidence they got in the 2nd step of inquiry. The discussions include how DNA analysis are used in crime investigations and also connects to content knowledge about DNA.	0.5

Table 1. Overview of CSI 3-stage teaching module

put forward as the focus in our study. Based on the definition and the importance of inquiry- and context-based teaching approaches, IC-BaSE is defined as letting students conduct an inquiry process in the sciences from a meaningful context. In the PROFILES project, IC-BaSE is embedded in a 3-stage approach: (1) contextualization (a context/scenario), (2) de-contextualization (scientific inquiry process) and (3) re-contextualization (socio-scientific decision-making and argumentation).

In line with the promotion of IC-BaSE, this study aims to investigate students' responses to the use of a PROFILES 3-stage module linked to the context of a crime scene investigation (CSI), based on a real case presented in the local TV news. A Likert scale questionnaire (composed in three parts of questions to let students compare their thoughts of a *perfect science lesson, the science lessons in their schools in general, and the CSI PROFILES module*) is given to students before and after the CSI module. The research questions are:

1. Is the CSI module preferred to students' science lessons in general in their school?
2. Is the CSI module preferable to students' thoughts of perfect science lessons?

Method

The participants and the PROFILES module

In the autumn 2013, six classes of 9-graders totaling 105 students, from two different schools, visited a science center at a university. The schools and the university were all located in a mid-size region in the middle-south of Sweden. The science center provided the students with a PROFILE 3-stage module activity which lasted for three hours (Table 1). The context of the activity was a real case of CSI which happened locally. Students were asked to conduct an inquiry process to find out which person did the crime.

The instrument and the design of the research

A Likert scale questionnaire was revised and developed based on the PROFILES MoLE questionnaire (Bolte, Streller & Hofstein, 2013; Bolte, 2006; Bolte & Streller, 2011; 2012). The scale had a ranking from one to seven from *not at all* to *very much*. The questions asked were:

1. The lessons in science are very fun or not fun at all.
2. I can understand the content of the lessons.
3. I have time to reflect on questions asked in science lessons.
4. The theme of the science lesson is important to my everyday life.
5. The theme of the science lesson is important to society.
6. I am active in science lessons.

With the same six questions, students were provided with three pages. The first page was for students to think of a perfect science lesson in their minds, and the second page was for students to reflect on their own science lessons in schools. The first two pages were answered by students before the CSI module activity. After the CSI activity, students were given the third page to reflect on the CSI module activity with the same questions. From this pilot study, the

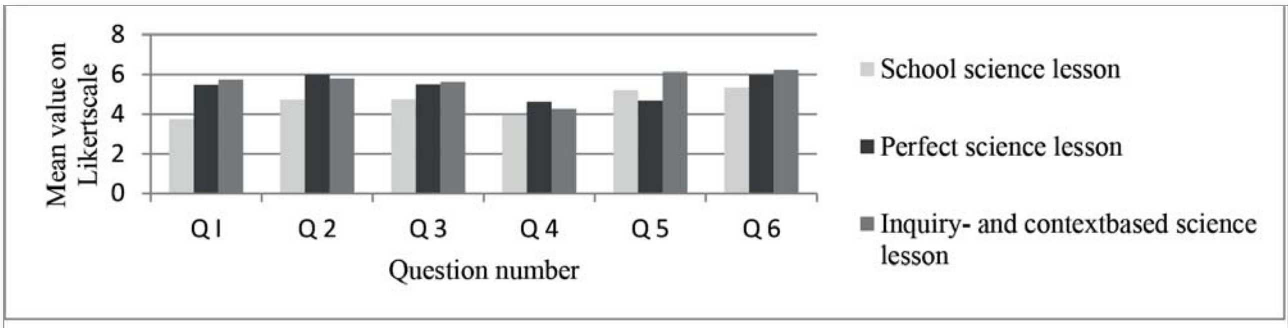


Figure 1. Mean values in questions concerning science lessons at school, a perfect lesson and an IC-based lesson

reliability was 0.771 (Cronbach alpha).

Data collection and analysis

Data were collected based on the three pages of Likert scale questionnaire. One-way ANOVA (SPSS software, version 22) was used to analyze the differences of students' perfect science lessons, their own science lessons in school and IC-BaSE (the CSI PROFILES) module.

Results

The results (see Figure 1) disclosed that the CSI module conducted in our study was significantly better than students' science lessons in school ($p<0.05$), except question four regarding the link of science to their everyday life. Concerning students' responses to the CSI module and their perfect science lessons in mind, we found that there were not significant differences among the questions, apart from question number five, which was about science in society.

Discussion and conclusions

Earlier studies (e.g. Gutwil-Wise, 2001; Kennedy, 2013; Parchmann et al., 2006) have shown that students' interests could be increased via IC-BaSE teaching. Our study confirmed these findings. In our study, the CSI module made almost all of the students interested in the sciences (question 1 shown in Figure 1). One surprise was that the students did not see the need of science being connected to society in their perfect lessons (question 5 in Figure 1). The reason for this could be that they were still too young to see science in society as important. Newton (1988) claimed that the individual perspective might be more important for younger children, but the societal dimension was more interesting and relevant as the child grew and matures. In addition, students' felt that perfect science lessons were more everyday-based (question 4 in Figure 1), but in our CSI module and their science lessons in school, this aspect was not achieved. Reflecting on this result, the content of CSI module was dealing with a crime scene and it was not part of their everyday life.

A study by Hsu and Roth (2010) found that students, who had the opportunity to participate in an internship with real scientists in a university setting, described their experience as meaningful because of the authentic nature. The results from our study might of course have been influenced by the learning environment being a laboratory, with good equipment and same kind of investigations as in a real crime-laboratory. Some of the participated students also asked about the jobs related to science laboratory during the break in the activity, which also showed that students' attention was captured via the CSI PROFILES module.

In sum, the CSI PROFILES module proved to be a suitable IC-BaSE teaching module in our study based on 105 students' responses. In our experiences working with in-service teachers, they very often mentioned that IC-BaSE teaching is too time consuming or hard to combine both context and inquiry approaches. In our study, we have presented a three hour IC-BaSE PROFILES module showing the possibility of conducting IC-BaSE in a reasonable timescale. Students' feedback is of importance for teachers to know, and the Likert scale questionnaire is also useful to investigate students' pre- and post-feedback on the teaching activity. This study is to contribute to IC-BaSE and science teachers' teaching practices.

Acknowledgement

We thank Prof. Claus Bolte's group for the original MoLE questionnaire. Also, we thank the students for their participation.

References

Bennett, J., & Holman, J. (2002). Context-based approaches to the teaching of chemistry: what are they and what are their effects? In J. K. Gilbert, O. De Jong, R. Jusiti, D. F. Treagust ,& J.H. Van Driel (Eds.), *Chemical Education: Towards Research-based Practice* (pp. 165–184).

Dordrecht: Kluwer.
Bennett, J., Lubben, F., & Hogarth, S. (2007). Bringing science to life: A synthesis of the research evidence on the effects of context-based and STS approaches to science teaching. *Science Education, 91*, 347–370.
Bolte, C. (2006). As Good as It Gets: The MoLE Instrument for the Evaluation of Science Instruction. In *Proceedings of the Annual Meeting of the National Association for the Research on Science Education (NARST)*, San Francisco, CA: NARST.
Bolte, C., Holbrook, J., & Rauch, F. (2012). Inquiry-based Science Education in Europe: Reflections from the PROFILES Project. Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).
Bolte, C. & Streller, S. (2011): Evaluating Student Gains in the PROFILES Project. *Proceedings of the European Science Educational Research Association (ESERA)*, Lyon, France. Retrieved from: http://lsg.ucy.ac.cy/esera/e_book/base/ebook/strand5/ebookesera2011_BOLTE_1-05.pdf (31.05.2012).
Bolte, C., & Streller, S. (2012). Evaluating Students Active Learning in Science Courses. *Chemistry in Action!, 97*, 13–17.
Bolte, C., Streller, S., & Hofstein, A. (2013). How to motivate students and raise their interest in chemistry education. In I. Eilks & A. Hofstein (Eds.), T*eaching chemistry – a studybook* (pp. 67–95). Rotterdam: Sense Publishers.
European Commission (EC). (2007). *Science Education Now: A renewed pedagogy for the Future of Europe*. Report by a High Level Group on Science Education. Brussels: EC.
Fensham, P. (2009). Real world contexts in PISA science: Implications for context-based science education. *Journal of Research in Science Teaching, 46*(8), 884–896.
Gutwil-Wise, J. (2001). The impact of active and context-based learning in introductory chemistry courses: An early evaluation of the modular approach. *Journal of Chemical Education, 77*(5), 684–690.
Hsu, P-L., & Roth, W-M. (2010). From a sense of stereotypically foreign to belonging in a science community: Ways of experimental descriptions about high school students' science internship. *Research in Science Education, 40*(3), 291–311.
Kennedy, D. (2013). The role of investigations in promoting inquiry-based science education in Ireland. *Science Education International, 24*(3), 282–305.
King, D. (2012). New perspectives on context-based chemistry education: Using a dialecticalsociocultural approach to view teaching and learning. *Studies in Science Education, 48*(1), 51–87.
Newton, D. P. (1988). *Making science education relevant*. London: Kogan Page.
Parchmann, I., Grasel, C., Baer, A., Nentwig, P., Demuth, R., & Ralle, B. (2006). Chemie im Kontext: A symbiotic implementation of a context-based teaching and learning approach. *International Journal of Science Education, 28*(9), 1041–1062.
Swedish National Agency for Education. (2013). *PISA 2012. 15-åringars kunskaper i matematik, läsförståelse och naturvetenskap. Resultaten i koncentrat. Sammanfattning av rapport 398.* Retrieved from: http://www.skolverket.se/om-skolverket/visa-enskild-publikation?_url_=http%3A%2F%2Fwww5.skolverket.se%2F-wtpub%2Fws%2Fskolbok%2Fwpubext%2Ftry-cksak%2FRecord%3Fk%3D3127 (11.01.2014).
Yeomans, E. (2011). Inquiry-based learning – what is its role in an inspiring science education? In *Perspectives on Education: Inquiry-based learning*. Wellcome trust. England. Retrieved from: http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_peda/documents/web_document/wtvm055190.pdf (11.01.2014).

4.27 Teacher Ownership from the PROFILES Project Perspective

Bülent Cavas – Dokuz Eylul University, Turkey

Abstract

The main aim of this article is to give information about Turkish science teacher ownership to implement PROFILES based teaching and learning environment in their classroom. The article begins with the meaning of teachers' ownership, defined by different sources, and then provides examples from Turkey about activities for teacher ownership. The experiences provided that CPD workshops and activities enhanced Turkish science teacher ownership to implement the PROFILES teaching and learning modules in their courses.

Introduction

As we all know, the scientific and technological development of a nation is directly related to science and technology education and, of course, science teachers as well. As we enter the new century on science and technology, the need to improve the teacher ownership about their science teaching is becoming urgent. For many years, the researchers have been working on various methods for improvement of teacher ownership. However, there are still no effective methods that are acknowledged at an international level. In order to help science teachers introduce better science teaching, we need to consider the entire educational system in which they function. It means we need to focus not only teacher in-service training, but also every aspect of ownership. Since the teacher ownership is a new component within the educational system, there is a need to explain the meaning of "ownership." The following section considers the meaning of "ownership" from a historical perspective and relates this to "teacher ownership," noting the definition of ownership changes according to the sources.

Ownership

> *"The question of the meaning of ownership, in this case of property, reaches back to the ancient philosophers, where Plato and Aristotle, held different opinions on the subject. Plato (428/427 BC – 348/347 BC) thought private property created divisive inequalities, while Aristotle (384 BC – 322 BC) thought private property enabled people to receive the full benefit of their labor. Private property can circumvent what is now referred to as the "tragedy of the commons" problem, where people tend to degrade common property more than they do private property. Given a short-sighted owner, however, a private property system can make these tragedies worse – for example, a private owner of a piece of oil-rich property, depending on his worldview, might be more interested in short-term financial gain than incremental use with an eye toward other's concerns (e.g. those of future generations, the disenfranchised, etc.). While Aristotle justified the existence of private ownership, he left open questions of (1) how to allocate property between what is private and common and (2) how to allocate the private property within society"* (Wikipedia).

This seems to imply that ownership relates to 'something' tangible. The definition of 'ownership' according to the several sources is written below:

> *"The ultimate and exclusive right conferred by a lawful claim or title, and subject to certain restrictions to enjoy, occupy, possess, rent, sell, use, give away, or even destroy an item of property."* (business directory).

> *"1. The state or fact of being an owner; 2. Legal right to the possession of a thing."* (The American Heritage Dictionary of the English Language, 2009).

> *"1. The state or fact of being an owner; 2. (Law) legal right of possession; proprietorship"* (Collins English Dictionary, 2003).

As is seen, the meaning of ownership is related to "possession of a thing," or legal right of possession. It is also important to know that ownership from a constructivist perspective is related to meaningful learning and it will always depend on the degree to which learners are able to make learning their own (Dudley-Marling & Searle, 1995, p. vii).

Teacher ownership

Teacher ownership has also various definitions according to different authors. For example, Kolderie (2002) explains teacher ownership as a form of entrepreneurship with considerable potential to change the practices and performance of the K-12 institution. Rannikmäe (2005) defines teacher ownership (by science teachers) as the phenomenon of adaptation of everyday teaching by the teacher, accordingly to a scientific and technological literacy philosophy. Kärkkäinen, Hartikainen-Ahia and Keinonen (2014) mention that teacher ownership is closely related to the identities of teachers as professionals, though teacher exhibit this in somewhat different ways. Some authors say it is leadership; others associate it with self-positivism; the PROFILES documents refer to it as a stage beyond self-efficacy (PROFILES, 2010). PROFILES partner from the Weizmann Institute defines ownership as:

> *"a sense of belonging towards the project among participating teachers; a feeling that the project belongs to them and is not imposed on them"* (Blonder, Kipnis, Mamlok-Naaman & Hofstein, 2008; Fullan, 2001).

What is not clear from the above is whether there is a common focus for teacher ownership. While the above suggest it is the teacher ownership of a way of teaching (a professional way), the term can also be applied to new techniques, new ways of working, or to the philosophy embedded within a project. Below we examine teacher ownership within the PROFILES project.

The development of teacher ownership in Turkey in the context of the PROFILES project

The following activities have been implemented during the project period in order to develop Turkish science teacher ownership of the philosophy and approach within the PROFILES project.

Continuous Professional Development (CPD) workshops:

All teachers working in state and private schools are responsible to follow a centralized science curriculum which is defined by Ministry of Education. The teachers need to obtain permission to attend any kind of seminar, conference etc. and put forward to promote teaching and learning activities. This, in order to invite science teachers to participate in the PROFILES project, official permission was requested by Dokuz Eylül University from the Educational Directorate of Izmir for teachers to participate. The Educational Directorate of Izmir checks the names of the teachers who are working in different region of Izmir and on acceptance sends an official invitation to their schools. In this way the science teachers attend the CPD workshops within the PROFILES project in Turkey.

The CPD workshops included a variety of activities related to the meaning of Inquiry-based Science Education (IBSE) and Education through Science (ES), and other aspects related to teacher identified needs. In addition, the Turkish CPD team asked teachers to share their knowledge and experience with other teachers in their school during all stages of CPD workshops.

During the CPD workshops, after theoretical sessions, each teacher was asked to prepare and present a PROFILES based teaching and learning module which they had (tried out/developed) and share their experiences during the implementation period. The teachers experienced the use existing PROFILES module, translated into Turkish and also had an opportunity to develop and share their own PROFILES module. The social media tools, e-mail groups, forums and newsletters, were used to provide effective communication among the CPD providers and teachers.

The modules were shared with teachers via the Turkish PROFILES website (www.profiles-deu.net).

Reflection on IBSE and modules

During the PROFILES seminar, the teachers were always interesting in learning what IBSE means and also about PROFILES modules. They reflected on their ideas about the translated PROFILES modules, which were viewed as funny and they modified these to use their own examples. They also created their own modules. It was found that when teachers were involved in creative group activities, it enhanced their affective feeling of togetherness, and the teacher felt good being part of the group.

A quote from a teacher's individual reflection:

> *"(...) My principal was asking me to give a speech to other science teachers about Inquiry-based Science Education. I had some ideas what IBSE means. However, after the PROFILES teacher seminar on this topic, I felt that my understanding about IBSE was completely wrong. I learned lots of information from the PROFILES seminar. Now, I am very happy and willing to organize a PROFILES seminar in my own school and want to share PROFILES philosophy & materials with other science teachers in my school (…)."*

Atmosphere to enhance ownership related to PROFILES – strong links

The teachers and CPD providers organized extra social activities in order to build strong links among the PROFILES team in Turkey. These activities provided strong links among the science teachers and CPD providers. For example, shy teachers asked more question about IBSE and their in-class implementation.

Pictures 1–4. CPD workshops in Turkey

Assessment of teachers' ownership towards PROFILES

In order to learn teachers' ownership level, data was collected in different ways. First, the data related to observations of teachers' performance during the CPD was collected and second, teacher feedback notes about the PROFILES seminars and modules were used to assess their sense of PROFILES ownership.

A short case-study of a science teacher who developed ownership regarding the PROFILES project

Simge, a science and technology teacher has taught science and technology for more than 10 years. She was very willing to attend PROFILES meeting and using her new found skills, develop PROFILES modules. She attended all PROFILES seminars conducted by the DEU-PROFILES team and clearly showed a strong appreciation of PROFILES ideas. She was invited to become one of the CPD providers in the second round when she clearly developed her ownership of PROFILES from her own perspective. Based on this she participated in the 1st Berlin PROFILES Conference (2012) and made an oral presentation on "Being a PROFILES Teacher: A teacher's view on developing teachers through CPD." Afterwards, she further exhibited her PROFILES ownership by informing other PROFILES teachers and her colleagues in school about the PROFILES conference. She further exhibited her PROFLES ownership by developing a PROFILES module on the animals which can be seen in zoos.

Her future role in promoting PROFILES philosophy and approach will more likely become invaluable for Turkey in the future.

Conclusions

The main aim of this paper is to give information about PROFILES teacher ownership and activities to increase teacher ownership about science teaching and learning in general. Our experiences related to teacher ownership during the PROFILES project indicated that CPD workshops and activities enhanced the Turkish science teachers sense of ownership to implement the PROFILES teaching and learning modules in their courses. This is potentially very important in Turkey.

In March 2012, the Turkish Grand National Assembly passed new legislation on changing primary and secondary education, in what is usually termed as "4+4+4" (four years primary education, first level, four years primary education, second level and four years secondary education). The students now begin their primary education in the first month of September following their sixth birthday attend school for eight years, which comes to a close during the school year in which students turn 14 years old. Students who are learning well can then continue for a further four years at the secondary level. In line with these changes in the educational system, curricula have been updated. For the first time, Inquiry-based Science Education is specifically included in the science curriculum. It is believed that PROFILES based teaching and learning modules and related CPD workshops will be good models to enhance Turkish science teachers' sense of ownership to adapt to the new educational system and eventually acquire ownership of the new curriculum approach.

References

Business dictionary. http://www.businessdictionary.com/definition/ownership.html

Collins English Dictionary – Complete and Unabridged. (2003). HarperCollins Publishers.

Dudley-Marling, C., & Searle, D. (1995). *Who owns learning?* Portsmouth, NH: Heinemann.

Kärkkäinen, S., Hartikainen-Ahia, A., & Keinonen, T. (2014). Teachers' Ownership: The Case in Mertala School. In C. Bolte, J. Holbrook, R. Mamlok-Naaman, & F. Rauch (Eds.), *Science Teachers' Continuous Professional Development in Europe. Case Studies from the PROFILES Project* (pp. 165–173). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Kolderie, T. (2002). "Teacher-Ownership as Entrepreneurship in Public Education" Institute for the Study of Educational Entrepreneurship (ISEE). Retrieved from: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.200.6378&rep=rep1&type=pdf

PROFILES. (2010). http://www.profiles-project.eu

PROFILES Turkey. (2010). http://www.profiles-deu.net

Rannikmäe, M. (2005). Promoting Science Teacher Ownership through STL Teaching. *Asia-Pacific Forum on Science Learning and Teaching, 6*(1).

The American Heritage® Dictionary of the English Language. (2009). Fourth Edition copyright ©2000 by Houghton Mifflin Company.

Wood, C (2003). The Effects of Creating Psychological Ownership among Students in Group Projects. *Journal of Marketing Education, 25*(3), 240–249.

Wikipedia. http://en.wikipedia.org/wiki/Ownership

5 PROFILES SCIENCE EDUCATION FAIR – PRACTICAL EXAMPLES FROM PROFILES TEACHERS

5.1 Pollen Exposes Food Fraud in Honey – Authentic Inquiry Learning in the Field of Palynology

Heidemarie Amon, Ilse Wenzl & Christine Heidinger – Austrian Educational Competence Centre Biology, Universität Wien, Austria

Abstract

The presented module[1] is oriented on the PROFILES criteria and gives pupils an insight into the world of forensic palynology and fosters the acquisition of an authentic notion and practice of science. Palynology is the "study of dust" (from the Greek word "strew, sprinkle") where particles, like pollen, are analysed to find answers to certain questions. Within the frame of the module, pupils independently generate knowledge about the theoretical background. In a next step they become palynologists themselves by controlling the varietal purity of commercially available honey and developing reproducible methods to determine the pollen found in honey. The multiple implementation of the module in class shows that the analysis of honey is a suitable introduction into palynology and familiarizes pupils with central characteristics to acquire scientific knowledge (i.e. creation and interpretation of diagrams, handling of errors, etc.).

Authentic inquiry learning

According to the teaching and learning approach of authentic inquiry learning (Heidinger & Radits, 2012), pupils are involved in authentic practices of a certain scientific discipline to enhance the learning process (Gelbart & Yarden, 2006) by simulating real research activities of scientists in class (Hay & Barab, 2001). Authentic inquiry-based assignments aim at providing pupils with a broad understanding of scientific practice as a prerequisite for building up an adequate perception of science (Allchin, 2011).

The scientific discipline of forensic palynology

Practicing palynology essentially means analysing pollen. Pollen grains, the male gender cells (gametes) of plants, are extremely robust and microscopically small. Because plants produce them in large quantities, pollen is found everywhere. Pollen differs in appearance (structure and ornamentation of the outer cell wall), therefore it can be assigned to plant families under the microscope. By means of pollen analysis, the Earth's climate in the past (climate research), as well as phylogeny of flowering plants, can be reconstructed (paleobotany). Pollen analysis is also useful in areas which are remote from scientific research: in food controls of honey it uncovers illegal product designations and within the field of forensics, it is established as a valuable method – along with finger prints and DNA analysis – for investigating crimes (forensic palynology).

The module „Pollen exposes food fraud in honey"

Within this module, pupils are introduced to the practice of food control of honey by means of pollen analysis. They learn how to create a pollen spectrum (see Figure 1) and to classify and count the pollen of a honey sample. Based on the pollen spectrum, they can draw conclusions to the plant species surrounding the hives and make statements regarding the varietal purity, as well as validity, of the information of origin.

The module was developed for the 8th grade level and is divided in two sections. It is oriented on the PROFILES 3-stage model including 1. a motivating scenario, 2. scientific/socio-scientific inquiry and 3. decision-making & argumentation. After a workshop with Jack Holbrook in 2013 it is planned to strengthen the third step of transferring the learning

[1] The module can be downloaded under the following link: http://ius.uni-klu.ac.at/misc/profiles/pages/materials

to a socio-scientific context, include the science in the decision-making and arrive at a consensus decision based on argumentation.

The level of difficulty can be adopted regarding the knowledge level of pupils and their capability of working independently.

In the first unit, pupils investigate how pollen can uncover food fraud in honey. The pupils plan their approach of completing the task, elaborate special concepts independently and consolidate them in discussions with the teacher (e.g. the characteristics of pollen and their role in the reproduction of plants, the correlation between pollen and honey, etc.) (Figure 2 and 3).

In the second unit, pupils become palynologists themselves by investigating how to control commercial honey. This includes the separation of pollen from the honey so as to make them visible under the microscope, as well as the development of a reproducible method for the determination and quantification of pollen grains. Based on these findings, pupils create a pollen spectrum.

Within the frame of this module, the teacher takes the role of a tutor offering strategies for solutions developed and approved by palynologists. Pupils have the opportunity to question the usefulness of these tools and strategies and to relate them to their own point of view.

[2] The section for teachers in the module contains the relevant background information.

The multiple implementation of the module in class shows that pupils are able to solve the task independently, in groups. The analysis of honey is regarded as a good introduction into palynology, because it can easily be conducted with the technical equipment of the school laboratory. Furthermore, the preparations from honey include different types of pollen grains in a manageable number that are clearly identifiable.

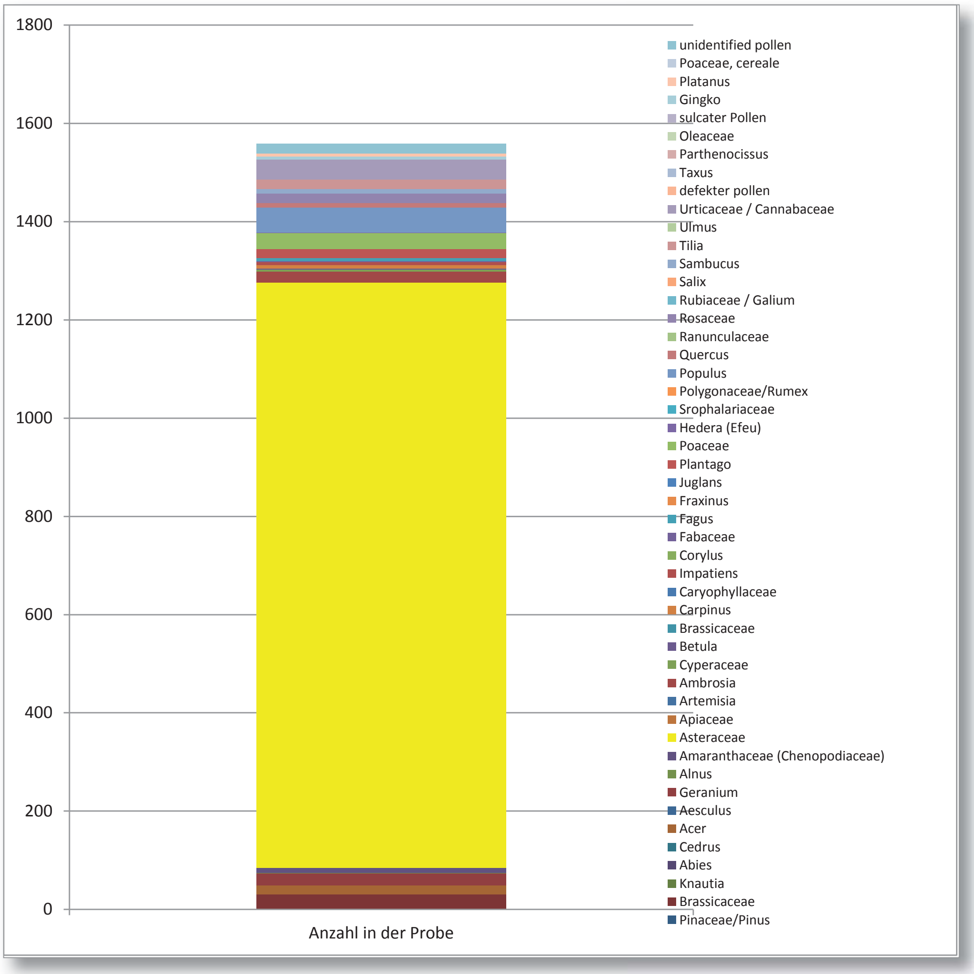


Figure 1. Pollen spectrum of a pure unblended sunflower honey by definition: The honey includes over 60% pollen grains from Asteracea (composite plants)

Building up scientific understanding

By involving pupils in authentic practices of forensic palynology and guided reflections of their work, pupils recognise central characteristics of scientific/biological research. They experience that scientific concepts (knowledge about the reproduction of plants, etc.) and research methods (classification of pollen types, creation of diagrams, etc.) are closely related within the context of practical application.

By working with the pollen spectrum, pupils also learn how scientists make natural phenomena visible, overseeable and interpretable, by means of graphical and tabular types of display (Roth & McGinn, 1998). Furthermore, the central problem of reliability of scientific results is treated as a topic. In the course of their work, pupils experience the difficulty of creating a reliable pollen spectrum that permits reliable statements about the varietal purity of honey. The accurate determination and quantification of samples is not easy to do for beginners. The continuous critical examination of their own procedure of researching helps pupils (and scientists) to find potential sources of errors (e.g. unsystematic scanning of the pollen preparation) and fosters the development of methods how such errors can be prevented. Only this assures the reliability of the generated results.

Figure 2. Pupils determining the pollen with a light microscope

Protokollblatt:

Datum: 2.10.2013 7.10.2013 Bearbeiterin: Marie-Sophie

Palynomorph	Zeichnung	Anzahl in der Probe	
Sonnen= blume			95
andere Pollen		|	1
andere Asteraceae		|	1

Figure 3. Excerpt of a pollen protocol: Every pollen grain found in the honey sample is determined and listed

References

Allchin, D. (2011). Evaluating Knowledge of the Nature of (Whole) Science. *Science Education, 95*(3), 518–542.

Gelbart, H., & Yarden, A. (2006). Learning genetics through an authentic research simulation in bioinformatics. *Journal of Biology Education, 40*(3), 107–112.

Hay, K. E., & Barab, S. A. (2001). Constructivism in Practice: A Comparison and Contrast of Apprenticeship and Constructionist Learning Environments. *The Journal of the Learning Sciences, 10*(3), 281–322.

Heidinger, C., & Radits, F. (2012). Authentic Inquiry Learning: Students and Scientists "On Equal Terms". In C. Bruguriere, A. Tiberghien, & P. Clément (Eds.), E-BOOK: Proceedings of the ESERA 2011 Conference (pp. 52–58). Lyon. Retrieved from: http://www.esera.org/media/ebook/strand2/ebook-esera2011_HEIDINGER-02.pdf (11.06.2014).

PROFILES. (2010). http://www.profiles-project.eu/ (11.06.2014).

Roth, W. M., & McGinn, M. K. (1998). Inscriptions: Toward a Theory of Representing as Social Practice. *Review of Educational Research, 68*(1), 35–59.

5.2 Fair of Innovative Science Education: "Robbery at the Jewelry Shop: Innocent or Guilty?"

Andreas Hadjistyllis & George Milliotis – Ministry of Education and Culture, Cyprus
Yiannis Georgiou & Eleni A. Kyza – Cyprus University of Technology, Cyprus

Introduction

"*After a robbery at a jewelry shop, the police arrested a young man two blocks away from the shop and found the silverware which had been stolen within a recycle bin nearby. The police detected filings of metal under the shoes of the suspect. The police believe that these filings are of silver and thus, the suspect is guilty. However, the suspect argues that since he works at a smelter, these filings are filings of magnesium, iron, copper or zinc. Can you decide if the suspect is innocent or guilty?*"

With a narrative based on the story presented above at its core, this innovative science fair activity aims to actively involve participants in a forensic investigation designed with the goal to increase students' conceptual understanding about reactivity of metals in chemistry.

According to the curriculum of the Cyprus Ministry of Culture and Education, the unit on metal reactivity is one of the basic chemistry units that 9th grade students cover. However, when employing a textbook-based instructional approach, students, in most of the cases, seem to lack motivation and interest, since they cannot understand how metal reactivity is related to their interests, or how this scientific knowledge could be of any importance in their everyday lives.

In an effort to address this situation, the chemistry teachers who participated in the PROFILES Cyprus professional development programme during 2013–14, decided to design an innovative inquiry-based PROFILES module, structured around the aforementioned narrative. According to the PROFILES chemistry teachers, instead of providing raw scientific knowledge, such a narrative has the potential to provide a meaningful context for young students to learn about metal reactivity, as well as to employ this scientific knowledge in order to solve a problem-based situation related to everyday life.

Hence, following the PROFILES design framework, these chemistry teachers developed an inquiry-based module for science education according to which students are:

(a) Introduced to an interesting problem-based scenario focusing on a situation that needs to be resolved.
(b) Asked to participate in an inquiry-based investigation in order to obtain the information needed.
(c) Asked to solve the problem-based situation by proposing an evidence-based solution.

What follows is brief description of the science fair innovative activity "Robbery at the jewelry shop: Innocent or guilty?" which is grounded on this inquiry-based module and is addressed to middle school students.

The innovative science fair activity

The innovative science fair activity which has a total duration of 40 minutes is divided in three distinct stages according to the PROFILES framework: (a) the socio-scientific scenario, (b) the inquiry-based investigation and (c) the decision-making.

During the first stage, the scenario is presented to the students through a short video, illustrating the forensic story. In this context, students are transformed as apprentices in the training group of Dr. Apostolou, who works in the Laboratory of Police Criminal Investigations. According to their mission, their goal is to help the police to solve the case, and thus, to decide whether the suspect is guilty or innocent. They are also informed that those students, who will accomplish their mission successfully, will receive an honorary certificate from the police department.

The stage of the inquiry-based investigation is divided in two different parts. During the first part, students investigate the reaction of four different metals (*magnesium, iron, copper, zinc*) with hydrochloric acid in order to sort out the four metals according to their reactivity. Through this experimental activity, students are expected to understand that when a metal is more active than hydrogen, then a chemical reaction takes place in which the metal displaces the hydrogen of its chemical compound. During the second part, students conduct the three following single replacement experiments: ($CuSO_4$ + Fe) / ($FeSO_4$ + Cu) / ($AgNO_3$ + Cu), in order to sort the three metals (Fe, Cu, Ag) according to their reactivity. Through this experimental activity, students are expected to understand that when a metal is more active than another metal, then a chemical reaction takes place in which the more active metal displaces the less active of its chemical compound.

Finally, during the stage of decision-making, students are asked to design their own experiment in order to detect if the filings under the shoes of the suspect are filings of silver or not, and thus, to decide if he is guilty or innocent. During this stage students are expected to employ the information they obtained during their inquiry-based investigation, in order to design an appropriate experiment and thus, to reach an evidence-based decision.

Overall objectives and competencies

For the accomplishment of this innovative science fair activity, as it has been presented in the previous sections, students have to be actively involved in a set of different scientific activities. More specifically, students are asked to express their predictions, to formulate and test their hypotheses, to design and carry out scientific measurements, and to make observations, to analyze and interpret their findings in order to reach in an evidence-based conclusion.

Hence, by participating in this learning activity sequence, students are expected to develop a conceptual understanding about metal reactivity, to improve their understanding of scientific inquiry and their experimental skills, as well as to improve their evidence-based reasoning and decision-making skills.

Concluding remarks

The implementation of this innovative science fair activity in five different public schools in Cyprus indicates an increase in students’ motivation to learn science as well as in students’ learning gains regarding metal reactivity. Taking into account these promising findings, we hope that this innovative science fair activity can capture the interest of middle school students, who participate in the 2nd International PROFILES Conference, and also the interest of other conference attendees.

Acknowledgement

This activity has been based on the PROFILES learning module developed by the PROFILES 2013–2014 Cyprus Middle School Chemistry Group, which was titled “Robbery at the Jewelry Shop: Innocent or Guilty?”. The following middle school chemistry in-service teachers participated in this group and co-designed the module: Yianna Symeonidou, Andreas Hadjistyllis, Eva Giakoumi-Hadjithekli, Lena Kyza-Pogiatzi, and Chrystalla Koumparou.

5.3 Experiments Supporting IBSE within PROFILES

Josef Trna, Eva Trnova, Nada Kopecka & Silvie Cervenkova – Masaryk University, Brno, Czech Republic

Abstract

The exhibition stand presents our research results on the implementation of experiments in inquiry-based science education (IBSE). Experiments are a core component of science education. IBSE is an educational method often based on experimentation and experiments have different roles in each of the four levels of IBSE (confirmatory, structured, guided and open experimentation). The primary outcome of our research is the taxonomy of experiments in each of the four levels of IBSE and here we present experiments on specific examples from physics, chemistry and biology. Each of our PROFILES modules include experiments, which are selected and modified according to the characteristics of IBSE and principles of their implementation. Our taxonomy for experiments in IBSE and the principles for their implementation into science education are an important need to be added into the continuous professional development (CPD) of science teachers. We see this task performed by the European project, PROFILES.

Introduction

IBSE is an approach to increase the knowledge and skills of the students in learning science (Hofstein, Navon, Kipnis & Mamlok-Naaman, 2005). Experimentation often plays an important role in IBSE because first-hand involvement is beneficial to promoting students' interest and participation in science activities (Haury & Rillero, 1994). Without interest (motivation) and participation we even go so far as to claim there can be no inquiry; nevertheless, our presentation does not aim to relate to all IBSE characteristics and focuses on presenting a set of experiments which are developed and implemented in the frame of PROFILES project (Trna & Trnova, 2012; Trnova & Trna, 2011). Although inquiry-based experiments can be interdisciplinary, especially if they derive from an everyday context, we present this specific set of PROFILES experiments under the separate headings of physics, chemistry and biology. This corresponds to common practice where science subjects are often taught in schools separately.

Figure 1. Body movement on an air cushion

Physics experiments which can be used in IBSE

In using physics experiments within IBSE, it is important that the experimentation is developed in line with the scientific question under investigation and leads the students to the desired scientific solution (Trna, 2012).

Also it is important to portray experiments appropriately in each of the corresponding IBSE levels. We thus present below a set of physics experiments, each associated with one of the four IBSE levels:

- Friction of a paper box and abrasive paper (experiment portrayed for confirmation inquiry)
- Friction of a wooden cuboid (experiment portrayed for structured inquiry)
- Friction of a different faces of body (experiment portrayed for guided inquiry)

- Friction of a different mass (experiment portrayed for guided inquiry)
- Friction of a different roughness (experiment portrayed for guided inquiry)
- Body movement on an air cushion (experiment portrayed for open inquiry)

Chemistry experiments which can be used in IBSE

The presented chemistry experiments are selected from our module on "Carbon nature of life." This module contains a set of interesting, simple experiments, portrayed for confirmation and structured inquiry, that are useful for chemistry in grade 9 (students aged 14–15). Below we present the set of five experiments:

- Chemical evidence for the presence of carbon in wood sawdust, sugar and potatoes
- Chemical evidence for the presence of carbon in paraffin by formation of soot
- Chemical evidence for the presence of carbon in paraffin formation of carbon dioxide
- Chemical evidence of the presence of carbon in the sugar reacting with copper oxide
- Chemical evidence of carbon in the sugar, flour and milk using fermentation

Biology experiments which can be used for IBSE

The presented biology experiments are selected from our module on "Safety of the human body: swimming and diving". The main objective of these simple experiments is to undertake investigations to ensure the safety of the human body. This set of interesting, experiments are useful in promoting biology instruction in grade 7–9 (students aged 13–15). Below we present the set of experiments portrayed for confirmation, structured and guided inquiry:

- Compression of lung
- Dissolving of an air in blood
- Ear-drum deformation under water
- Ear-drum rupture under water

Figure 2. Chemical evidence for the presence of carbon in paraffin by formation of soot

Figure 3. Ear-drum deformation under the water

References

Haury, D. L., & Rillero, P. (1994). *Perspectives of Hands-On Science Teaching*. Columbus: ERIC-CSMEE.

Hofstein, A., Navon, O., Kipnis, M., & Mamlok-Naaman, R. (2005). Developing Students Ability to Ask More and Better Questions Resulting from Inquiry-Type Chemistry Laboratories. *Journal of Research in Science Teaching, 42*, 791–806.

Trna, J. (2012). How to motivate science teachers to use science experiments. *Journal of Systemics, Cybernetics and Informatics, 10*(5), 33–35.

Trna, J., & Trnova, E. (2012). Inquiry-based Science Education Experiments. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based*

Science Education in Europe: Reflections from the PROFILES Project (pp. 212–215). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Trnova, E., & Trna, J. (2011). Hands-on experimental activities in inquiry-based science education. In *Proceedings book of the joint international conference MPTL'16 – HSCi 2011. (pp. 293–298).* Ljubljana: University of Ljubljana.

5.4 Finnish Teachers' Experiences with PROFILES Teaching

Susanne Bergström-Nyberg – Mattliden School
Marita Liukku – Mertala School
Petri Luukkainen – Joutseno High School
Maarit Maksimainen – Sampo School
Raija Malinen – Taavetti High School
Marketta Pellinen – Mertala School, Finland

Six different stories

How teachers experience PROFILES teaching is dependent on the background and practices of the school. In this story, the schools in question are situated in different parts of the country and vary in size. The High School in Luumäki is the smallest with its 60 students and Mertala School, in Saolinna, the largest with over 600 students. Mattlidens skola in Espoo, is the only Swedish-speaking school; Finnish is the teaching language in the other schools. Two of the teachers teach in High Schools and the rest teach grades 7–9 (lower secondary school). Table 1 presents the schools and the learning environments. Susanne, Marketta and Marita participated in the first PROFILES CPD Programme, and Maarit, Raija and Petri in the second one.

Experiences with PROFILES teaching

Reflection and awareness of one's own practices are essential for successful CPD (e.g. Taitelbaum, Mamlok-Naaman, Carmeli & Hofstein, 2008; Berry, Loughran, Smith & Lindsay, 2009). The experiences put forward here are ones highlighted in – focus group discussions at a PROFILES workshop meeting in April 2014. The discussion is based on modified and self-created PROFILES modules (Table 1). Selected comments are given.

The scenario stage was considered to be very challenging and the main concern was how to find a relevant scenario which related to students' lives and was of interest to them. We perceived that PROFILES training had helped us to understand the role of the decision-making stage; also that the multiple viewpoints related to the scientific problem and the links with society were new to us.

> *"Like you, I think we are already using inquiries in basic education, but this has clarified the instruction. Having the context scenarios, then coming to the decision-making stage, increases inquiry more (...) than earlier."*

After experiencing PROFILES, teaching methods were less teacher-centered than before.

> *"…this really encourages me to put the students to work themselves rather than me teaching them all the time and the students are copying (…)"*

Interdisciplinary themes provided opportunities for students to extend their thoughts through inquiry. The role of the teacher was to help students to understand different perspectives as well as to find their own meanings for learning, to integrate ideas and understanding in their own way. This was viewed as very difficult for some students and they felt that they were not learning.

Teacher	Town	Subjects	Students at school	Students in PROFILES	Modified Learning Environments	Created Learning Environments
Susanne	Espoo	Chemistry Physics	300	120	CSI Electricity bill Corrosion	
Petri	Lappeenranta	Physics Mathematics	160	60		Space
Maarit	Tampere	Physics Chemistry	520	30	Corrosion	
Raija	Luumäki	Physics Mathematics Chemistry	60	37		LED Light Energy
Marketta and Marita	Savonlinna	Physics Chemistry Mathematics	665	215	CSI	Water Food Energy (Marketta) Energy (Marita)

Table 1. Teachers, their schools and learning environments

> *"…some students, particularly the good ones who one would have thought would learn anyway; these however experienced that they were not learning…"*

> *"… one of the students was really angry, asking why don't you tell me what to do and how…"*

In the discussion, we spoke of the need to prepare students for the new learning style, helping them to reflect on their learning and demonstrate what they have learned. It was also considered that PROFILES taught using student evaluation; for example, project work was assessed instead of exams and the role of different skills was highlighted instead of content knowledge. This kind of evaluation was experienced as being particularly useful for both teacher and student in the case of low-achievement students.

As well as needing time and a flexible schedule, we experienced that PROFILES teaching approach also needed the support of the school community in order to apply PROFILES modules to real classroom situations. Not only some, but all teachers should have the possibility to collaboratively reflect, both on how their modules were applied in the classroom and how to make the module better for the next time. Expanding the PROFILES model to other school subjects and other grades would also be a possibility in big schools, but where there was a lack of other teaching staff this would not be so easy. Table 2 presents the strengths, weaknesses, challenges and threats that we experienced with PROFILES.

Comments by the CPD provider

In addition to the PROFILES CPD programme, the Finnish CPD providers have participated in the renewing process of the Finnish Core Curricula, drawing attention to the science education approaches which are in line with PROFILES. Ideas from PROFILES can be seen in the draft of the curriculum (Finnish National Board of Education, 2014). The PROFILES assessment model is in accord with that in the curriculum's draft, also the curriculum's cross-curricular themes support the PROFILES approach: the perspectives of science issues moved from being individually self-centered towards being aspects at the societal level. A representative of the Finnish National Board of Education has actively been involved in the PROFILES project and has been a mediator for inclusion of PROFILES ideas into the curriculum.

In the future, the University of Eastern Finland (UEF) plans to participate in the so-called LUMA (LU meaning sciences, MA mathematics) Project, funded by the Ministry of Education and Culture and led by the University of Helsinki. It is a national project carried out in connection with the LUMA centres in Finland. The project is a six-year project aiming to motivate students towards scientific and mathematical studies and careers. UEF plans to provide the project with an example of PROFILES 3-stage model teaching within teacher professional development. The target is to get 80% of the Finnish municipalities to become involved in the LUMA project's activities. Considering these plans for the future, PROFILES is expected to have an enormous effect in Finnish schools and the PROFILES 3-stage model can be expected to have a significant role in teacher education; it is one teaching model that will also be presented to teacher students.

References

Berry, A., Loughran, J., Smith, K., & Lindsay, S. (2009). Capturing and Enhancing Science Teachers' Professional Knowledge. *Research in Science Education, 39,* 575–594.

Finnish National Board of Education. (2014). Retrieved from: http://oph.fi/english/curricula_and_qualifications/basic_education

Strengths	**Weaknesses**
• from teacher-centered, content oriented approach to inquiry based learning • PROFILES modules stimulate student's own intrinsic motivation (positive attitude toward physics and chemistry) • teachers' continuous professional development (CPD) • modified modules – local aspect • decision-making stage • continuous assessment instead of tests	• new style for teaching physics and chemistry – some students think that they do not learn • lack of peer supporting groups: in a small school there is only one physics and chemistry teacher
Challenges	**Threats**
• connections to everyday life outside of school (e.g. Savonlinna) • co-operation in school with other teachers • new curriculum is in line with PROFILES ideas • scenario stage – how to find an interesting, good scenario • the role of information and communication technology	• flexible timetables in schools : how to find time for inquiries during 45 minute sessions • inquiry-based learning needs resources: how policy makers and community understand the role of PROFILES

Table 2. Strengths, weaknesses, challenges and threats experienced in the PROFILES context

(24.07.2014).

Taitelbaum, D., Mamlok-Naaman, R., Carmeli, M., & Hofstein, A. (2008). Evidence for Teachers' Change While Participating in a Continuous Professional Development Programme and Implementing the Inquiry Approach in the Chemistry Laboratory. *International Journal of Science Education, 30*(5), 593–617.

5.5 "Bio-Plastics – a Real Alternative?" Development of a PROFILES Module for Chemistry in Grades 11/12

Marlies Gauckler, Rebecca Emmerling & Josefine Graf – Freie Universität Berlin, Germany

Abstract

The PROFILES module "Bio-Plastics – a real alternative?" was developed to promote inquiry-based science learning (IBSL) through "student centered teaching, posing a scientific question, seeking evidence for an acceptable answer to the question and focusing on student gains, associated with the learning activities" (Bolte et al., 2012, p. 32). The focus of the module is a critical evaluation of bio-plastics as a "greener" alternative to conventional petroleum-based plastic. The omnipresence of plastic in students' everyday life, as well as the enormous amounts of waste caused by non-biodegradable plastic are used as a starting point for a discussion about alternatives. Over the course of the module, students investigate and produce different types of bio-plastics, compare properties and test bio-deradability. Then, they assess aspects of sustainability of the tested types of bio-plastics from different perspectives in a debate. Finally, they reflect on their attitudes towards bio-plastics based on scientific evidence and draw conclusions for their own life. At the science fair, we will present some of the student experiments that form an essential part of the module: we will provide the opportunity to produce different types of bio-plastics and to observe their bio-degradability in comparison with store-bought bio-plastics and traditional types of plastic.

Socio-scientific issues-based chemistry teaching

The topic of bio-plastic was chosen because it is becoming increasingly present in students' lives (e.g. in packaging, electronics, automotive, toys and textiles), and will gain further importance in the future (European Bioplastics: Market, 2013). Examples of bio-plastics like these can be used to make the topic accessible, motivating and relevant for students. The topic is also suitable to illustrate scientific but abstract concepts such as sustainability and protection of the environment through students' decisions as consumers in their everyday life. What is more, an issue like bio-plastics provides a socio-scientific context (Sadler & Dawson, 2011) which is suitable to tie science learning to the 'real world' and, following the PROFILES approach of "education through science", can guide students to appreciate the relevance of science learning for lifelong learning, responsible citizenry and preparing for meaningful careers (Bolte et al., 2012).

Specifically, the module follows the socio-critical and problem-oriented approach, in which students learn "that science can be the basis for understanding a topic, but that decisions about such an issue always are influenced by different interest groups" (Eilks, Rauch, Ralle & Hofstein, 2013, p. 27). The chosen topic fulfils this approach's criteria for authenticity, relevance, evaluation undetermined in a socio-scientific respect, allowing for open discussion and dealing with questions from science and technology. Our lessons follow the structure proposed by Eilks et al. (2013) of textual approaches and problem analysis (lessons 1–2), clarifying the chemistry background in a lab environment (lessons 3–7), resuming the socio-scientific dimension and discussing and evaluating different points of views (lessons 8–9) and closing with a meta-reflection (lesson 10). The methods suggested for this approach are realized in the form of authentic newspaper articles, student oriented chemistry learning and inquiry-based lab work, learner-centered instruction and cooperative learning methods, as well as a controversial debate structured as a role play and finally questions which provoke the explication of individual opinions.

Contents

The module addresses the following contents for chemistry as described in the Berlin curriculum for grade 11/12 (Senatsverwaltung für Bildung, Jugend und Sport Berlin, 2006):

- Connections between chemistry, everyday life and society, e.g. the ecological consequences of chemical processes and recent technologies considering the aspect of sustainability and the importance of chemistry for solutions to global problems
- evaluating chemical and scientific statements from different perspectives and assessing them based on chemical evidence
- importance of biopolymers
- plastics: structure, properties and production
- analysis of structure and properties of synthetic polymers and exemplary production of plastics.

Learning outcomes

In this module, students learn to

- discover plastics and bio-plastics in their everyday life
- critically evaluate everyday use of plastic objects
- produce and investigate bio-plastics
- conduct experiments and interpret results
- present scientifically correct arguments based on chemical knowledge, evidence from experiments and research in recent media
- discuss controversial topics from the perspective of different interest groups
- reflect on their own consumer behavior.

Module description

The module was developed for 10 lessons of 45 minutes for chemistry students of grade 11/12.

Lesson 1–2: "A life full of plastic?"

In preparation for the topic, students are asked to note every plastic object they encounter during an average day to make them aware of the fact that life without plastic is almost impossible. In *lesson 1*, the students compare and visualize their lists. After the omnipresence of plastic is established, students are confronted with the problem of waste caused by non-biodegradable plastics. As homework, students are encouraged to think about plastic objects they could do without, and alternatives to conventional plastics. The results are collected in the following *lesson 2*, in which students name alternatives to everyday plastic objects, for example replacements made of wood or glass, or in some cases bio-plastics. In groups, students then investigate different bio-plastic products, e.g. biodegradable bags, packaging chips made of corn starch, candy wrappers made of polylactic acid and PlantBottle™ (The Coca Cola Company, 2012). Each group poses questions about their product, which are shared in increasingly bigger groups, until the class as a whole arrives at the most interesting five to eight questions, which then serve as guidelines for the following lessons.

Lesson 3–7: "Investigating bio-plastics"

In *lesson 3 and 4*, students try to find a viable definition of bio-plastics and critically discuss the meaning of "bio". In group work, they then produce different types of bio-plastics made from lactic acid, starch, sorbitol and casein. *Lesson 5* features a market place activity, in which the groups present to the class their product, its production method and its applications. In the following *lesson 6*, students compare the properties of their produced bio-plastics with both store-bought bio-plastics and petroleum-based plastics to find out if bio-plastics could be suitable alternatives to conventional plastics. At different stations, they test visual impression, combustibility, solubility and presence of starch. In *lesson 7*, students investigate the bio-degradability of different types of plastic. As this process takes a long time, it is recommended that the teacher prepares this experiment at least ten weeks in advance. The teacher cuts different types of plastic into pieces of the same size and places them in a compost heap. Students compare the visual impression of decomposition and apply the results by evaluating suitable materials for a trash bag.

Lessons 8–9: "Debate: bio-plastics – a real alternative?"

Students connect the knowledge gained during the preceding lessons to social implications by discussing bio-plastics as an alternative to petroleum-based plastics from different perspectives in *lessons 8 and 9*. The debate is organized similar to popular political talk shows, which feature representatives from different interest groups. Students step into roles of people involved with the topic and prepare arguments with the help of authentic material such as newspaper articles and press releases. A moderator leads the debate. All other students are audience members, and they prepare a Facebook post expressing their opinion, which they will read out during the show. The outcome of the debate is open and depends on the research and debating skills of the students.

Lesson 10: "Reflection on bio-plastics"

The final *lesson 10* offers the opportunity to reflect on the lessons as a whole and on the result of the debate on a personal level. Students give their opinions and reasons on bio-plastics as an alternative to petroleum-based plastic. They list advantages and disadvantages, considering the production, properties and sustainability of the investigated bio-plastics. In addition, they reflect on their attitude towards bio-plastics and describe if and in what ways their attitude changed throughout the lessons. Finally, they reflect if the lessons will have consequences for their future lives. The students write down their results and respond to other students' ideas in writing. The lesson ends with a feedback from the students on their experiences with this method of learning.

Conclusion

The module "Bio-Plastics – a real alternative" provides a context for learning that follows the PROFILES 3-stage model for motivational IBSE (Bolte et al., 2012; Holbrook & Rannikmäe, 2012) by first arousing students' intrinsic motivation through a familiar socio-scientific context, then sustaining motivation throughout the main inquiry-based learning stage and finally providing the opportunity for reflection on the scientific issues in the initial socio-scientific context. In this way, the lessons might have a substantial impact on students' attitudes and future lives.

References

Bolte, C., Streller, S., Holbrook, J., Rannikmäe, M., Hofstein, A., Mamlok Naaman, R., & Rauch, F. (2012). Introduction into the PROFILES Project and its Philosophy. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 31–42). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Eilks, I., Rauch, F., Ralle, B., & Hofstein, A. (2013). How to allocate the chemistry curriculum between science and society. In I. Eilks & A. Hofstein (Eds.), *Teaching Chemistry – A Studybook*. Rotterdam: Sense.

European Bioplastics (2013). Retrieved from: http://en.european-bioplastics.org/market/ (20.05.2014).

Holbrook, J., & Rannikmäe, M. (2012). Innovative Inquiry-based Science Learning Environments in the Framework of PROFILES. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 52–55). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Sadler, T. D., & Dawson, V. (2012). Socioscientific issues in science education: Contexts for promoting key learning outcomes. In B. J. Fraser, K. G. Tobin, & C. McRobbie (Eds.), *International Handbook of Science Education* (pp. 799–809). New York: Springer.

Senatsverwaltung für Bildung, Jugend und Sport Berlin (2006). *Rahmenlehrplan für die gymnasiale Oberstufe Chemie*. Retrieved from: www.berlin.de/imperia/md/content/sen-bildung/unterricht/lehrplaene/sek2_chemie.pdf (20.05.2014).

The Coca Cola Company (2012). PlantBottle Basics. Retrieved from: http://www.coca-colacompany.com/stories/plant-bottle-basics (20.05.2014).

5.6 Using PREZI-Technology to Promote Inquiry Learning on Bionics: Two Further Modules

Moritz Krause, Dörte Ostersehlt, Judith Meile, Lea Griemsmann & Ingo Eilks – Universität Bremen
Torsten Mehrwald, Hans-Jürgen Runden, Uwe Heering & Steffi Mroske – Lise-Meitner-Schule, Kooperative Gesamtschule Stuhr-Moordeich, Germany

Abstract

Within the PROFILES project in Bremen, teachers have developed their own teaching and learning modules as part of their continuous professional development. One group of teachers decided to develop computer-based teaching and learning materials on bionics for the lower secondary science classroom. Altogether three modules were developed. A first module on the lotus effect was already presented in an earlier PROFILES project book. In this paper another two modules on "The gecko on the wall" and "From the bird to the plane" have been discussed. All modules focused on inquiry learning, based on a computer learning environment that was structured by the software PREZI.

Introduction

Continuous developments in information and communication technology (ICT) allow for constant change in the way science is taught (Dori, Rodrigues & Schanze, 2013). Computers, tablet PCs, interactive whiteboards and smartphones make computer-based learning environments available in the classroom in a completely new way. Tasks, tutorials and assessment can be implemented in a much more individualized fashion. Many studies showed that the use of ICT can promote learning achievements (Dori et al., 2013). That is why a group of teachers in the PROFILES project in Bremen decide to learn about the use of modern developments in ICT for promoting inquiry learning as part of their continuous professional development (CPD). Since the didactical perspective is crucial for positive effects when using ICT (Kerres, 2000) the teachers not only start learning about the technology itself, but they decide to develop complete teaching and learning modules based on an ICT learning environment. The topic chosen is bionics (Krause et al., 2014).

Developing teaching and learning modules based on PREZI

PREZI is quite new software, developed for presentation purposes. PREZI can be understood as a more powerful version compared to traditional presentation software, such as Microsoft PowerPoint. The idea of PREZI is based on a large desktop surface, where content in the form of slides can freely be arranged. The slides can also be assigned to different levels so that the content can be networked in a three-dimensional structure. Slides can be re-arranged to a specific order. However, with zooming in and out the desktop, any point of the information network can also be approached directly at any time. Such a technology allows for the creation of learning environments that are both structured and open. If learning content is arranged in a way students can follow a learning trajectory given in the learning environment, but at the same time, can move from one piece of information to another. PREZI also offers rich possibilities to integrate different media types and allows for presenting the content in more a dynamic fashion. For a more detailed description see Krause et al. (2014).

Within different curriculum development projects in the PROFILES project in Bremen, PREZI is used for the development of teaching and learning modules. One of these projects has focused on teaching about bionics in the lower secondary science classroom. A group of teachers, accompanied by curriculum experts from the University of Bremen, have worked for about two years on the development of different modules. The developments have followed the approach of Participatory Action Research in science education as described by Eilks & Ralle (2002). since this has proved to be an effective strategy for both curriculum development and teachers' CPD (Mamlok-Naaman & Eilks, 2012). The group has met regularly once a month for a whole afternoon for developing ideas, creating teaching materials, and reflecting on experiences and evidence collected in the classroom. All together three different teaching and learning modules have been created.

Figure 1. Suction cup Gecko under vacuum.

The teaching and learning modules

Three modules were developed – *'The lotus effect,' 'The gecko on the wall'* and *'From the bird to the plane'*. The three modules encompass a whole set of activities. Students were asked to do experiments, to develop their own models, to read and write. Also various types of media were integrated, e.g. worksheets, photos and videos. All the information, media and tasks were integrated into PREZI environments that in the end were embedded together in a web-page for learning about bionics (www.chemiedidaktik.uni-bremen.de/multimedia/bionik).

In each of the three modules, students are introduced to the topic by short and exciting stories. From the stories and by activating their prior knowledge the students have many opportunities for student-active and inquiry-based learning. The mode of the tasks changes between structured and guided inquiry. Individual steps and hints are available in the PREZI environment, as there are also ideas for investigations and experiments to solve the problems in question.

While the module on the lotus effect has been presented in an earlier publication from the PROFILES project (Krause et al., 2014), this paper presents another two modules. Within the module *The gecko on the wall* the story in the beginning raises the question why the gecko is able to climb up the wall. The students receive a wide variety of commonly known materials such as suction cups, magnets, Post It's, sticky tape, hooks, liquid glue, etc. The students are allowed to play freely with all the materials. They need to find out which functions are present on the Gecko's foot so that the gecko can climb vertically on walls, or windows. The students are encouraged to make hypotheses about potentially relevant explanations and to test them by observations and investigations. For example, the students receive a plastic gecko with suction cups. They can observe that the reason for the adhesion of suction cup is a vacuum (Figure 1) and it seems that a gecko foot may have a similar structure. For further understanding, the students can access an explanation video produced by one member from the group. In the video, the students observe that the suction cups do not grip onto a glass wall in a vacuum area, but based on information, the students learn that a gecko's foot still adheres. So the students can exclude the sucker cups as the structure on the gecko's foot. More information is provided e.g. about the concept of van-der-Waals forces that are responsible for the adhesion of the gecko's feet. For assessment, further worksheets and quizzes are available in the learning environment. With the van-der-Waals concept, the students are now able to understand the phenomenon and they can extend their knowledge by further investigations, e.g. about a device called 'Nanopad'. Students can try out how the Nanopad works and how powerful it is.

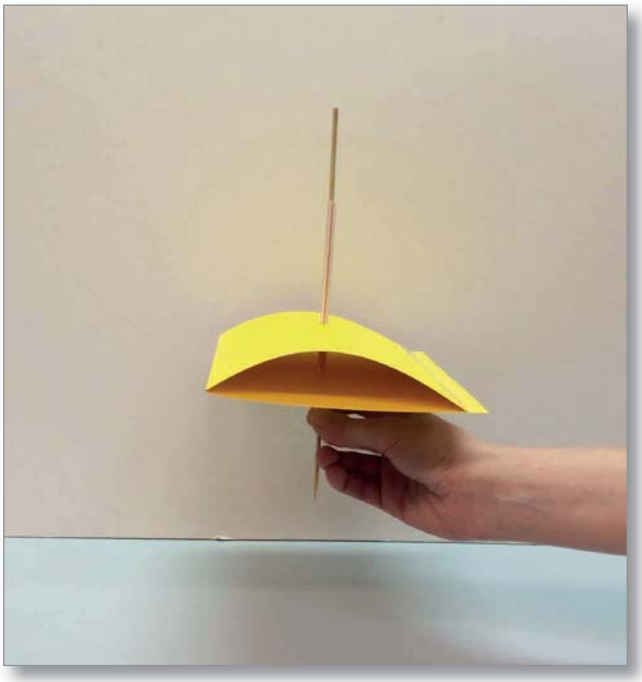


Figure 2. Model of an airplane wing

The third module '*From the Bird to the plane*' focuses the inspiration of watching birds to invent flying aircraft. The module starts with a historical review about Leonardo da Vinci, the first bionic, Otto Lilienthal, the pioneer of aviation, and the Wright brothers and their first powered flight. The learning process is than inspired by various photos and videos. The students compare the shape and structures of birds' wings and the ones of airplanes. Similarities and differences are highlighted. The learners are encouraged to create their own models of wings (Figure 2) and to test the models' behavior. Within the learning environment, the students discover and work out the various physical concepts that play a role in the process of flying. A learning-at-stations lab (Eilks, 2002) is offered to integrate the different activities. At each station, small experiments and videos are available focusing on e.g. over pressure, under pressure, Bernoulli's principle, and ascending force. The learning-at-stations phase leads to another explanation video to find the final explanations.

Conclusions

Within the CPD programme of the PROFILES project in Bremen, computer-based teaching and learning environments were developed for teaching different aspects of bionics. Many different activities, media elements and assessment tasks were integrated into three PREZI environments available to schools via the Internet. Each of the modules was tested in ten learning groups. Feedback was collected from teachers and students. Initial evaluation of the data indicates that the learning environments were very motivating to the students, both from the content and the ICT-based pedagogy.

It seems that PREZI learning environments are valuable tools for enriching the pedagogy of science education. PREZI meets the students ICT experience from using smartphones and tablet PCs. They provide a modern impression of presenting content and activities. Such environments have great potential to support individualized, self-directed and inquiry-based science learning. It also fosters cooperative processes of creating meaning by multiple forms of approaching the content and exchange about it within the learning group.

References

Dori, Y., Rodrigues, S., & Schanze, S. How to promote chemistry learning through the use of ICT. In I. Eilks & A. Hofstein (Eds.), *Teaching chemistry – A studybook* (pp. 213–240). Rotterdam: Sense.

Eilks, I. (2002). "Learning at Stations" in secondary level chemistry lessons. *Science Education International, 13*(1), 11–18.

Eilks, I., & Ralle, B. (2002). Participatory Action Research in chemical education. In B. Ralle & I. Eilks (Eds.), *Research in Chemical Education – What does it mean?* (pp. 87–98). Aachen: Shaker.

Kerres, M. (2000). Mediendidaktische Analyse digitaler Medien im Unterricht. *Computer und*

Unterricht, 10(1), 26–28.
Krause, M., Ostersehlt, D., Mehrwald, T., Runden, H.-J., Mroske, S., & Eilks, I. (2014), Using PREZI-Technology to promote inquiry-based learning on 'bionics'. In C. Bolte, J. Holbrook, R. Mamlok-Naaman, & F. Rauch (Eds.), *Science Teachers' Continuous Professional Development in Europe: Case Studies from the PROFILES Project* (pp. 149–158). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).
Mamlok-Naaman, R., & Eilks, I. (2012). Action research to promote chemistry teachers' professional development – Cases and experiences from Israel and Germany. *International Journal of Mathematics and Science Education, 10*, 581–610.

5.7 BONES: Whose Skeleton is This? A Grade 11–12 Biology Module on the Anatomy of the Human Skeletal System

Marco Peter Ferretti – Liceo Statale "Enrico Medi", Senigallia, Italy

Abstract

We present a grade 11–12 life science (biology) module, aimed at motivating students to learn the anatomy of the human body, implementing Cooperative Learning (CL) and Inquiry-based Learning (IBL) strategies. In this activity, students investigate a simulated "crime scene", set up with plastic replicas of human skeletal elements. They examine the bones, take notes, document evidence and take pictures. The goal of the investigation is to attribute the skeletal remains to a specific individual (the "victim") from a list of five missing persons. To solve the "case", students need first to pose the right questions and then collaborate with each other in order to collect and analyze all the relevant data from the skeletal remains. In so doing, they learn basic notions of the anatomy, development, and sexual dimorphisms of the human skeleton and dentition. In addition, students familiarize themselves with techniques used in crime scene investigation (CSI) for age and gender assessment of skeletal remains, and develop skills for scientific inquiry, including the ability to interpret data and communicate results. Due to the popularity of such crime and investigation TV shows as "CSI", "NCIS" and "Bones", the proposed activity proves to be particularly attractive to young students, promoting their interest and motivation toward science learning.

Introduction

The recent reorganization of the Italian school system ("Riforma Gelmini") redefined the curricula, standards and objectives of High School (scuola secondaria di secondo grado) courses.

According to new guidelines set by the Italian Ministry of Education (MIUR), at the end of the fifth (conclusive) year of high school, students should: have acquired an autonomous method of study, allowing them to conduct investigations and insights; be able to support their own thesis and know how to listen and critically evaluate the arguments of others; have acquired the habit of reasoning with logical rigor; be able to identify problems and possible solutions, and finally, with regard to the scientific disciplines, be able to master the procedures and methods of scientific investigation. These are similar goals to those of the PROFILES project (Bolte et al., 2012). However, these expectations often clash with the reality of teaching practices in Italian schools, which are focused on lectures and become almost utopian in those courses in which the weekly hours of science are reduced to two (e.g. language and classics lyceums). Unfortunately, in this way, the active participation of students in the learning process is in fact limited to the mere listening, with the frequent result of decreasing their motivation for learning. The only occasions when the active participation of students is explicitly required are those situations dedicated to solving application problems and for laboratory work. Even in these activities, however, the student is expected, most of the time, to follow established procedures (laboratory protocols, standard schemes of resolution of the problems, etc.).

Figure 1. Students analyse the lower limbs

To meet the new national guidelines imposed by the Italian ministry of education, teachers need to implement strategies that invite the students to ask questions, to reflect on the phenomena and objects that surround them and to seek the means for obtaining answers. Only in this way it is possible to motivate the student to "want to know more," a fundamental prerequisite for an effective learning process (Holbrook, 2010). The module presented in this paper is based on inquiry and cooperation, and consists in the resolution of a fictitious criminal case that makes use of human bone replicas, pretending they are the remains of a homicide victim. Students are asked to assign those remains to a specific individual, choosing from a list of five fictitious missing persons, for whom personal and physical information are provided. Pupils need to cooperate with each other, ask the right questions and understand what information they must retrieve from the skeletal remains in order to solve the "case". Eventually they necessarily have to acquire knowledge about the anatomy of the human skeleton, its ontogenetic development and sexual dimorphism, as well as skills related to the description of bone elements, the organization of data and presentation of results of a scientific investigation.

Curriculum content and target

The learning content of the module relates to the anatomy, organization and development of the human dentition and skeleton. They are among the specific learning objectives indicated in the MIUR national guidelines, which establish, in the last two years of high school, the study of the form and function of organisms, with particular reference to the human body. The module is therefore aimed at grade 11–12 students (4th and 5th year), depending on the specific programme schedule adopted by the teacher.

Prerequisites, learning and competency expectations

Among the prerequisites considered useful for a more successful implementation of the module, we recall knowledge of the steps of the scientific method to be used, the SI units of measurement, the determination of measurement uncertainty, fundamental characteristics of living things, cell structure, and the organization of the human body. The educational aims of the module are to develop the following skills in students: make logical connections, recognize or establish relationships, classify, formulate hypotheses based on the data provided, draw conclusions based on the results obtained and on the hypotheses that have been put forward, solve problematic situations using specific language, and apply their knowledge to real life situations.

Material and methods

The activity was performed using a teaching quality replica of a disarticulated human skeleton plus some elements from other skeletons. To set the lab, the skull, the pelvis and trunk, the upper limbs, and the lower limbs were placed on 4/5 tables, depending on the number of student groups, by the teacher. Each skeletal element was given a number using an "evidence label". Each group of students were handed pre-printed cards for the collection of data and a form to complete for the final report. During the analysis of the findings, students were required to measure the bones with gauges and extensible meters, photograph them with their mobile phone cameras, identify the bones and furnish a brief description. The data were reported on the appropriate card. In the methods of analysis, to determine if the remains belong to more than one individual, students checked if there were duplicated bones (e.g. two right humeri) or bones were at very different developmental stages (e.g. immature, adult). The age of the individual to whom the remains pertained was estimated from the stage of fusion of the epiphyses of the long bones, from the fusion of the cranial sutures, or from replacement and wear of the teeth. Finally, gender assessment was based either from the shape of the skull or, more reliably, from that of the pelvis.

Figure 2. Another group analyse the upper limbs

Module structure and content

The activity is divided into five phases.

Step 1. The case is presented to the students, who are divided into four or five groups. Bones of possible homicide victims are shown to the students, together with a list of five missing persons of different ages and gender. Students-investigators are asked to figure out to which of the five missing people on the list these remains belonged. At this stage, it is left to the students to take the opportunity to ask questions of any kind to the teacher, who then marked the most significant on the blackboard. This phase ended when the students understood that they must derive from the bones three fundamental pieces of information: 1) whether they belong to one or more individuals; 2) the age of the individual's skeleton 3) the gender.

Step 2. In the second stage, the groups of students began to discuss among themselves and tried to figure out how to get that information from the bones. Depending on the time available, the teacher could provide some references, or allow students to research independently, at school or at home, the necessary information from texts and online resources. At the end of this stage, methods found by various groups were discussed together with the teacher, until all groups agreed on what were the best methods to implement.

Step 3. In the third phase, the teacher gave students background information on the anatomical features of the human skeleton and dentition, the manner of their development and maturation, and the differences between the female and the male skeleton.

Step 4. In this step, each group was assigned to the analysis of a specific aspect of the investigation, which included: 1) determination of the number of individuals represented by skeletal remains, 2) determination of the age of the remains; 3) gender assessment. The students, through the use of anatomical plates and growth charts, analyzed the findings assigned to them, and successively transcribed their comments on the appropriate forms. At the end, each group produced a report in which they specified the material analyzed, the method used to obtain the information sought (number of individuals / age / gender) and their conclusions.

Step 5. Each group presented their results to the others, if possible through the use of multimedia presentations. The results of the various groups were then compared to ensure they were consistent with each other and in case of incongruence, a discussion was started to find out possible methodological errors.

Final assessment

At the end of the module, the work done by various groups of students, summarized in the final report produced by each group, will be evaluated by self-assessment, assessment by members of other groups and eventually by the teacher. The teacher will also take account of how well students interacted in cooperative groups, their hard work, the quality of their presentation and their participation during the school year.

Conclusions

The purpose of this activity is three-fold. First, to arouse a keen interest in the study of the anatomy of the human skeleton; second, to allow students to experiment with the methods used in a scientific investigation, including the reporting of results; and third, through the simulation of a detective investigation, the activity is intended to make students understand how the "theory" learned in school applies to "real – life" situations. Most of the students involved in the activity found it interesting and challenging and somewhat funny. What they enjoyed most was being able to find a way, scientifically valid and shared by all, to solve "the case". Last but not least, students involved in the "Bones" activity, earned on the average significantly higher examination grades than those who were taught the same content through a conventional lecture.

References

Bolte, C., Streller, S., Holbrook, J., Rannikmäe, M., Hofstein, A., Mamlok, R., & Rauch, F. (2012). Introduction into the PROFILES Project and its Philosophy. In C. Bolte, J. Holbrook, & F. Rauch. (Eds.), *Inquiry-based Science Education in Europe. Reflections from the PROFILES Project* (pp. 31–42). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Holbrook, J. (2010). Education through science as a motivational innovation for science education for all. *Science Education International, 21*(2), 80–91.

5.8 The Implementation of Selected Modules of the PROFILES Project in Poland

Sylwester Baryła – High School in Parczew
Agnieszka Kamińska-Ostęp – Faculty of Chemistry, Maria Curie-Sklodowska University, Lublin
Katarzyna Kuśmierz – High School in Borzechów, Poland

Abstract

Teachers need to constantly raise their qualifications, seek new professional challenges and make their classes attractive for students. One way for them to improve the quality of their teaching and develop their professional skills is participating in projects such as PROFILES, as is the case for the teachers described in this article.

The article presents information, opinions and conclusions related to implementing three modules, designed according to the guidelines of the project. The modules are adapted to the knowledge and skills in the Polish core curriculum and to typical classroom conditions in Polish schools.

Module 1: "How does the type of soil influence plant growth?"

This module was implemented in the form of five double extra-curricular sessions. During the first class the students were divided into groups and were told about the content and aims of the module. The students then divided the tasks among themselves within the groups and planned the experiments they were going to conduct. At the end of the class, they were taught how to extract soil samples and to prepare them for the experiments.

The second and third classes took place in the laboratory. The students brought in soil samples from nearby fields, riverbanks and roadsides, and the materials needed to carry out the experiments that they had bought in stores. First they described the physical properties of the samples, i.e. their colour, smell, structure and any rock material. Then they examined the samples using a microscope. In another experiment, they determined the type of soil using a system for soil classification. They also determined the permeability and pH of the soil, as well as the amount of carbonates. This was followed by an experiment whose aim was to determine the influence of liming on the pH of the soil. The group leaders presented their observations and conclusions. During the discussion the students found it necessary to conduct experiments which would make it possible to investigate the influence of soil salinity and acidity on the growth of plants. These experiments were later carried out according to the procedure developed by the students.

In the fourth lesson, the results of the studies conducted were discussed. During the fifth lesson, the students made concluding remarks and expressed their opinion regarding the following issues:

- Do climate conditions influence the quality of the soil and if so, in what way?
- How do organic and chemical fertilisers influence plant growth?
- What are the soil requirements for genetically modified plants and what are the environmental risks associated with them?
- Can plants be an indicator of the type of soil?
- What are the conditions for cultivating plants in greenhouses?

Module 2: "How to use cleaning products in an effective and safe way?"

This module was implemented in the form of four extra-curricular classes, which were preceded by an introduction that made it possible to organise them effectively. The students completed the following tasks, before the lessons started:

- Check what cleaning products you use at home and be ready to explain what you use them for. Give five examples.
- Bring five cleaning products to class in their original containers.
- Gather information concerning the products using different sources. When searching for information focus on the main active ingredient (the Material Safety Data Sheet).

In the first lesson, the students presented the cleaning products they had brought with them. During this lesson, the teacher explained why the issues covered in the module were important and what its aims were. The teacher emphasised that there was a wide range of available products and discussed the commercial aspect of the customers' decision to buy them. The teacher also encouraged the students to reflect on the following issues:

- Why are the cleaning products effective?
- What chemical substances make them work?
- How do they work and how can they be replaced?
- Are they toxic for people or the environment?
- Are commercials for such products reliable?

After the students discussed the products they had brought to class, the products were classified into five groups: lime and rust removers, stain removers and bleaches, cleaning and disinfecting products, drain cleaners, and detergents. Each of the groups of products was assigned to a different group of students.

In the next lesson, the students carried out group work, followed by a whole-class summary. The students completed the following tasks: deciding which substances determine the properties of the products, choosing experiments which were to help determine the basic chemical properties of the substances, designing the procedure for carrying out the experiments, and deciding how the students' observations should be recorded. This also involved preparing reagents and laboratory equipment. In the following lesson, the students conducted the experiments they had planned and prepared a report on the procedure they had followed, as well as on their observations (also in the form of photos and clips) and conclusions. In the last lesson, groups of students presented the results of their work, which were discussed together with the remaining students and the teacher.

Module 3: "How can we avoid wasting energy and reduce the operating costs of buildings?"

In the first lesson, the teacher discussed the issues which were to be covered in the module. The students learned about the operating costs of residential and public buildings, and about the depletion of natural resources which were the source of thermal energy. This led the students and teacher to formulate the problem which was to be the focus of the module i.e. the necessity to save energy.

The second lesson concerned the methods of generating energy (locally – to heat residential buildings, nationally, and on a global level, taking into consideration the level of economic development, available natural resources, etc.). Another important issue discussed in this lesson was the effectiveness and costs of using different sources of energy and the by-products obtained in the process, which were dangerous for the environment.

The next lesson concerned building materials used now and in the past. The students discussed their physical properties (thermal conductivity and resistance to physical forces), as well as their durability and price. Some other issues included factors which influenced the choice of materials in the climate conditions in Poland and the introduction of new materials with increasingly better properties. The students also analysed the causes of wasting energy related to its transmission and the design of buildings. This prepared the students for the next lesson, in which they explored the ways to avoid and reduce wasting energy.

The aim of the last lesson was to show students that the knowledge they had gained could be very useful, in particular when they became adults. The students were to design an energy-efficient home, using the information they had acquired. All of the classes were based on information which the students had collected on their own. They were highly interested in the issues covered in the module and often approached them in a creative way, proposing unconventional solutions.

Figure 1. Students working on the module on soil

Conclusion

The inquiry-based learning method which was used in the study made the students highly active. The method required creativity, involvement in every stage of the learning process, and an ability to obtain and use information effectively. It not only fostered the students' individual development, but also made it possible for them to learn how to work in groups. Planning and carrying out the experiments allowed the students to formulate hypotheses and verify them experimentally i.e. gain knowledge though trial and error. Observing the experiment, reporting on it and drawing conclusions put the students in the role of researchers, which gave them much satisfaction. Summing up, their work and the presenting of their findings helped the students to organise the knowledge they had gained and draw general conclusions. As far as assessment is concerned, the combination of teacher and self-assessment did not generate too much excitement among the students, but it had significant education value.

Implementing the modules required re-organising the education process and providing the students with the necessary laboratory equipment. Moreover, the teacher did not play the role of a purveyor of knowledge, but that of a guide who supported the students and monitored their work.

The students who participated in the study acknowledged that inquiry-based learning required their active involvement in the education process. It did not allow them to be passive in any of its stages. They needed to take ownership of the topics they were researching and they were motivated to work diligently and systematically. The students also said that their involvement was positively influenced by having an opportunity to conduct experiments, including planning them independently. They felt that solving the problem depended solely on their skills, diligence and involvement. However, some of the students had difficulty working in groups, since conflicts arose when students worked at different paces. Finally, it is worth mentioning that the groups devoted much attention to preparing their posters, films and presentations in order to present all of the stages of their work as best they could, and that the students saw the assessment carried out by their teacher and peers as objective.

5.9 CIA – Color in Action: Can You See It?

José Gonçalves – Agrupamento de Escolas de Amarante & Universidade do Porto
Nuno Francisco – Colégio Cedros, Colégios Fomento & Universidade do Porto
Carla Morais, José Barros & João Paiva – Faculdade de Ciências da Universidade do Porto, Portugal

Abstract

This stand is about the materials produced during the application of a PROFILES module in a Portuguese school to students between 12 and 15 years old. The module includes a teacher's guide, educational materials, and instructions to build a color box. It is recognized that it is very important to apply a pre-test and post-test to know student's misconceptions about this topic and their evolution. The materials can be acquired easily and at low cost. Variations can be made to improve the color box, or a degree of freedom can be given to students to enhance their creativity. It is intentional to use PhET's[1] simulation to understand, visualize the phenomena and guide student's conclusions.

Introduction

The "CIA – Color In Action" was the result of a module implemented in Portuguese schools with success. This module was created during PROFILES teacher's training promoted by the University of Porto. The materials produced in that training included a teacher plan to implement a scenario, and student's worksheets to guide students in experimental and simulation exploration. The materials were designed to teach using an inquiry methodology using videos to increase student's curiosity (Figure 1). Finally, the module includes a pre-test and post-test to follow student's development and identify some student's misconceptions.

Color In Action

The "CIA" tries to present tools used in the original module implemented in Portuguese schools, based on the situation "Have you ever wondered why our cloth change color in the disco?" (A scenario to contextualize and promote, through de-contextualized IBSE, the study of introductory light, color and matter) (PROFILES, n.d.), with more interesting tools regarding light and the topic of color.

[1] Interactive Science Simulations of physical phenomena from the PhET™ project at the University of Colorado. http://phet.colorado.edu/

The intention of this module is to motivate students and then build students' knowledge through an active and guided investigation. Teacher need to distribute the students into small groups and use some videos in classroom as the contextual scenario to raise students' curiosity. After this step students participate in a brainstorming session within their groups to put forward scientific questions with predictions on how to solve the problem. The next step is experimentation to solve the problem question(s). The teacher can guide students in the construction of a color box. In that box, students can insert different objects, cover the box with a colored cellophane sheet and illuminate the inside with a flashlight shining through a hole made in one side of the box. It can be very interesting if students use different light sources and try to predict what they expect to see.

The teacher can complete the study through this module by showing to students some applications and videos related to light and color. We suggest a YouTube video related to HUBBLE's photos and how scientist colored the collected images.

In the fair, we present the tools described above, and some new materials not included in the original module. The first material is a mobile spectrometer (Foldable Spectrometer, n.d.), that consist of a tiny spectrometer built with black cardboard, put in a smartphone camera to take pictures of a spectrum created by a light source (Figure 2). The second material is to color images taken by Faulke's Telescope Project (2008).

Figure 1. Materials of the "CIA – Colour In Action"

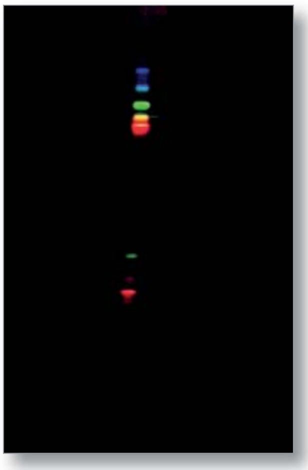


Figure 2. Spectrum from a fluorescent lamp

Students interact with this box and register their observations on a first worksheet. To continue and consolidate their observation and results, students can interact with a PhET simulation on a laptop, or any computer in the classroom. Their observations and conclusions can be registered in a second worksheet.

A test of colour-blindness can be conducted by students with their peers and local community. By developing their own poster, the results can be published on the school's website, Facebook and other media. Also, students can develop a poster to present their results to the school and local communities, and finally to a local health center.

References

PROFILES (n.d.). *Módulos Profiles*. Retrieved from: http://www.profiles.org.pt/?page_id=156 (09.06.2014).

EufisicaTV (n.d.). *Foldable Spectrometer.* Retrieved from: https://www.youtube.com/watch?v=RdwJOAukpiY (09.06.2014).

Faulke's Telescope Project (2008). *Faulke's Telescope Project*. Retrieved from: http://www.faulkes-telescope.com/ (09.06.2014).

5.10 Promoting IBSE in Primary and Secondary Education Through Hands-On Science Activities

Gabriel Gorghiu, Laura Monica Gorghiu, Ana-Maria Suduc & Ana-Maria Petrescu – Valahia University of Targoviste
Niculina Zuga – Constantin Cantacuzino National College Targoviste
Mihaela Anghel – Ienăchiță Văcărescu National College Targoviste
Mirela Cristina Negreanu – National Centre for Staff Training in Pre-University Education, Ministry of Education, Romania

Abstract

Science is closely connected with our lives. Nothing that surrounds us can be explained without involving science phenomena and their application in practice. Even though science knowledge is undergoing huge developments and the future of our planet is directly connected with science and the way we are using this knowledge for the benefit of our world, science lessons are not top of students' preferences in many countries. Therefore many programmes and projects are devoted to increase students' interest in science lessons. In the frame of those projects, many teacher initiatives have been undertaken in order to explain to students the importance of science and its huge involvement in their everyday life. A main goal is to motivate students to study science (Biology, Chemistry and Physics). The "PROFILES – Professional Reflection Oriented Focus on Inquiry-based Learning and Education through Science" Project is trying to put forward answers to this objective. In this respect, the Romanian PROFILES stand at the science fair – organized in the frame of the PROFILES Conference (Berlin 2014) – proposes some interesting experiments, designed by Romanian teachers within PROFILES modules, implementable in pre-primary, primary and secondary education.

Introduction

The existence of life is closely connected with the presence of water. Since water is an important component of biological fluids, those fluids are also closely related to our daily life. Therefore, noting the importance of water and biological fluids for our life and health it is important for students to know about and understand this area. Thus, teachers from all education levels have reflected on topics related to those aspects in PROFILES modules, designed after their participation to the CPD programme "*PROFILES – Education through Science*" (Gorghiu & Gorghiu, 2014).

Secondary education experiments

An integrated PROFILES module entitled "*Is the plants food natural? What happens to substances dissolved in groundwater?*" was designed by Niculina Zuga – teacher in Constantin Cantacuzino National College Targoviste – for 7th grade students (Zuga, 2012). In this module, the students have the opportunity to examine capillarity, a phenomenon present in everyday life. During the designed activities, students can investigate the solutions and the porous materials properties by different experiments, such as solutions switching from a container to another through different membranes, the floating of the bodies denser than water, the concept of surface tension of water. The students can perform also various experiments meant to emphasize the phenomenon of capillarity by experiencing the rising of water solutions in different plants, and collecting/processing the data.

The stand shows some practical experiments designed in the frame of this module, as follows:

The investigation of photosynthesis to Elodea Canadensis (common name: Water Plague)

Materials: Elodea Canadensis branches, Erlenmeyer glass, water, light source.

Procedure: Some *Elodea* branches will be placed in an Erlenmeyer beaker filled with water. To accelerate the photosynthesis, the flask is placed on a sunny ledge or lit by a bulb. After couple of minutes, bubbles (oxygen) become visible in the glass.

Figure 1. Oxygen bubbles on the surface of **Elodea Canadensis**

Figure 2. Placing a paper clip on the surface

Figure 3. Floating the paper clip on the surface

Why water droplets are round?

Materials: tweezers, paper clips, glass, water.

Procedure: A Berzelius glass will be filled up with water and using tweezers, a paper clip is placed gently on the surface of the water. The paper clip floats on the water surface because the water molecules form a film on the surface, able to support bodyweight. The force that holds molecules united is called *surface tension*. When the cup is filled, the surface curvature can be observed closely. The surface tension tends to pull water into a curved shape and very small volumes of water adopt a round shape – the familiar drop of water. A strong enough membrane occurs because of the surface tension of water.

How soap interacts with the surface of the water? Holes in the water.

Materials: pepper, water, liquid soap, crystallizer.

Procedure: Fill the crystallizer with water and sprinkle pepper on the water surface. Insert a finger into the water. What happens? If only fingering the film formed on the surface, the pepper deforms with no wetting. Explanation: The surface tension is an intensive force that is interrupted only when the finger is inserted. Take a drop of soap liquid on a clean finger and stick it into the water through the pepper spread on to the surface. It can be observed that the pepper moves away from the finger spot; if the finger motion is repeated on the pepper surface, water holes can be noticed.

Figure 4. Sprinkling the pepper on the water surface

How is the water moving? Water rising.

Materials: a branch of celery (*Apium graveolens*) with leaves (approx. 20 cm in length), Erlenmeyer flask, blue and red ink.

Procedure: The beaker is filled with water and a few drops of ink added. A stick of celery is put into the coloured water and the beaker is placed into a warm place. In time, the branches and the celery leaves become coloured with the ink. Why? If the celery branch is cut, it can be observed that it is composed of small tubes by which the coloured water rises to the leaves. Water is ascending in the thin capillary tubes as it is drawn up. This is the capillarity phenomenon that allows plants to absorb water from the soil through its roots and to transport it to the leaves.

Figure 5. Inserting the finger into the water with pepper

Figure 6. Inserting of the liquid soap on the water surface

Figure 7. Moving away of the pepper from the finger spot

The flower that is blooming in water

Materials: sheet of paper, filter paper, markers, scissor, crystallizing apparatus.

Procedure: Make two identical flowers using the two papers (like in the figure below) and colour them. Bend the flower petals to the inside and put the flowers on to the surface of water. What happens? The flower made from filter paper is bursting suddenly while the other is opening slowly. Explanation: The water penetrates by the capillary tubes from the empty spaces in the paper fibres and extends them making that the petals to redress and the flower to bloom.

Figure 8. The quickly blooming of the flower made by filter paper on the water surface

Figure 9. The slowly blooming of the flower made by normal paper on the water surface

Water and solutions transportation by porous materials

Materials: two Erlenmeyer beakers, water, ink, ammonium nitrate, calcium hydrogen phosphate, cleanser, napkins.

Procedure: One beaker is half filled with water, ink solution, ammonium nitrate and cleanser solutions. A second beaker is placed near the beaker containing the solution. By twisting a napkin, make a connection between the two beakers. What is happening? The water and other solutions will be transported into the empty beaker by the napkin bridge.

Figure 10. Preparing the solutions

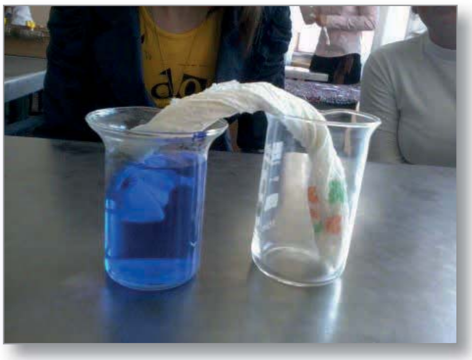


Figure 11. Connect the beakers by a napkin bridge

Figure 12. Ascending of the water solution up the napkin bridge

The rising of the sap by different wood essences

Materials: three Erlenmeyer glasses, red and blue ink, ammonium nitrate (chemical fertilizers), cleanser, perches from different wood essences (fir tree, linden tree, oak tree).

Procedure: In each glass will be prepared one kind of sap: water with red or blue ink, water with chemical fertilizers, and water with cleanser. The perches (three of each kind) will be inserted in each glass. What is happening? The sap from each glass will rise in time in different manner from glass to glass and perch to perch.

Figure 13. Transport of the water solutions into the empty beaker

Figure 14. Ascending of the water solutions on different wood essences

Figure 15. Ascending of the water solutions on different wood essences

Explanation: It is hard to understand the manner in which the sap is rise on the plants, and particularly on the high trees up to heights of 50 or even 100 metres. The sap contains beside water, minerals and nutritive substances, also residues that must be eliminated. The circulation is made in both ways. From bottom to up, the sap flows by continuously channels, composed by dead (inactive) cells.

From up to bottom, the circulation takes place by structures composed from living (active) cells. From the physical point of view, it is important only the first way (down to up).

In addition, in order to emphasize the importance of life and the connection between science and the creation of life, a set of presentation sheets will be exposed on the Romanian PROFILES stand, in order to show the activities designed by Mihaela Anghel – teacher at *Ienăchiță Văcărescu National College Targoviste* – in the PROFILES module entitled "*Could a sterile couple conceive a child?*" – developed for 10th grade students (Anghel, 2012). The module allows students to address a current problem not only in Romania, but also in the whole world, namely infertility in young couples. Students investigate the case of a young couple, who are unable to conceive a child, despite attempts over a year. Those activities give students the opportunity to investigate this case in successive stages, step by step. A set of presentation sheets emphasizing the different stages of the students' activities are exposed on the stand. The activities of the unit proposed to students to study the anatomy and physiology of the human reproductive system, the conception, intrauterine development and rules to be observed by prospective parents in order to have a healthy baby, the causes of male and female infertility. In the last part, the couple opportunities with the in-vitro fertilization technique are presented.

Pre-primary and primary education experiments

Due to the fact that in the last year of PROFILES project, some PROFILES modules have been adapted and implemented by non-PROFILES teachers from *pre-primary and primary education*, the Romanian PROFILES stand include some experiments designed by teachers for 5 to 10 years old students. It is very interesting to see how teachers adapted the science experiments in order to introduce them to young students and explained them, not only the scientific content but also to make them aware about the importance of the studied phenomena in their daily life. Four of those experiments are presented in the following paragraphs.

I was the first here! Two forms of matter that cannot occupy the same place at the same time.

Materials: one Berzelius beaker, some beads with different sizes, water, adhesive label.

Procedure: Half fill a beaker with water. Stick an adhesive label on the beaker, in order to mark the level of the water. Drop some beads, one by one, into the beaker. Check the level of the water. What happens? The level of water is higher than before. Explanation: Water and beads are both two different forms of matter and they cannot occupy the same space. When the beads are placed into the beaker, they are heavier than water, so they roll to the bottom of the beaker and push the water from the occupied space. Therefore the water level rises above the marking tape.

The salt that disappears.

Materials: one Berzelius beaker, a cup, hot water, salt, stirring stick.

Procedure: Fill the beaker with hot water. Measure a cup of salt and pour it very slowly into the beaker of water without the water run out of the glass. You can eventually stir the mixture with the stick. What happens? If you pour carefully, you can add around a cup of salt into the glass of water without the water overflowing. Why? Water does not flow out from the beaker when salt is added, because an extra space is required. The water molecules have spaces between them. Those spaces are filled with molecules of salt, like pouring sand into a jar full of beads. The sand makes its way through the spaces between the beads. Such an orderly arrangement between two substances is called *forming a solution*.

1+1 doesn't make always 2!

Materials: one Berzelius beaker, a cup, hot water, sugar, stirring stick, adhesive tape.

Procedure: Paste adhesive tape on the outside of the beaker. Pour a cup of hot water into it and mark on the tape the level of the water. Add then another cup of warm water and again, mark the water level on the tape. Empty all water from inside the glass and dry it with a paper towel. Now, pour a cup of hot water into the beaker. Now add a similar cup of sugar into the water. Mix this solution well with a straw and then check the fluid level on the strip of tape. The level of the mixture composed by a cup of water and a cup of sugar do not touch the level of two cups of water marked on the tape. Explanation: If you have learned the key word – *solution* – when you were instructed to mix the sugar with the water together, you probably already know the answer. The components of solutions are harmoniously mixed, such as pieces of a puzzle. Instead of taking up space, sugar grains fill the empty spaces surrounding the water molecules to create something entirely new, a solution called sugar water ... but occupying less space than you thought it would have when you mixed the cup of water and sugar.

Can we obtain clear water from a dirty one?

Materials: 4 Berzelius beakers, 4 Erlenmeyer glasses, 4 glass funnels, 2 pieces of gauze, 2 pieces of filter paper, water, sand, dry leaves, sawdust, corn flour.

Procedure: Fill four beakers with a cup of water each. Pour into each of them sand, dry leaves, sawdust or corn flour. Use pieces of gauze or filter paper and pour the "dirty" water through those pieces of gauze or paper put into four glass funnels placed each on the four flasks. The process used for obtaining clear water is called *filtration*. After a while, you will obtain clear water from the dirty one. Explanation: After this experiment, the pre-primary / primary students discover that the dirty water can be cleaned of impurities by different methods. Therefore, the water can also be purified, and no longer be contaminated. Students understand that there are many types of materials and substances that may pollute water and affect our way of living and the environment in general. They realize that creatures cannot survive in polluted water and the polluted water cannot be consumed.

References

Anghel, M. (2012). *PROFILES Module – Could a sterile couple conceive a child?* Retrieved from: http://profiles.ssai.valahia.ro/pg/expages/read/Program/ (30.05.2014).

Gorghiu, G., & Gorghiu, L. M. (2014). Analysing the Relationship between the Effectiveness of the PROFILES Continuing Professional Development Programme and the Dissemination/Networking Process. In C. Bolte, J. Holbrook, A. Hofstein, & F. Rauch (Eds.), *Science Teachers' Continuous Professional Development in Europe. Case Studies from the PROFILES Project* (pp. 267–277). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Zuga, N. (2012). *PROFILES Module – Is the plants food natural? What happens to substances dissolved in groundwater?* Retrieved from: http://profiles.ssai.valahia.ro/pg/expages/read/Program/ (30.05.2014).

5.11 Slovenian Teachers' Views About Development and Implementation of PROFILES Modules in Their Lower Secondary School Science and Biology Classrooms

Mira Metljak & Iztok Devetak – Faculty of Education, University of Ljubljana
Katja Dragar – Primary school Trbovlje
Lilijana Homovec – Primary school Črni Vrh
Tatjana Dominič Radivojevič – Primary school Ivana Babiča-Jagra Marezige, Slovenia

Abstract

This paper on the PROFILES project by the Slovenian partner is presented from the teachers', members of the PROFILES network, point of view. The designed modules are described and the uptake of active learning by students is shown, introduced by the Slovenian national PROFILES team. Three modules are presented: two for general science lessons, „Can I really be a whole orchestra?" and „Ouch, my head hurts. How can I help myself the quickest way?", and one for biology lessons, „Should athletes undertake high altitude training?", with examples of experiments that are performed independently by students. Also group work and cooperation between teachers, as an important part of the professional development programme, is pointed out; team work was very intensive in module designing. The paper is concluded by indicating strengths and deficiencies of the project, expressed by teachers. Teachers found the project an important asset to their professional development and in the development of competence in more self-confident teaching. Also the impact on students was evident, but more with respect to the gifted students, who found the PROFILES approach as both interesting and engaging them to further individual research.

Background and framework

The PROFILES project, as an intensive teachers' professional development (TPD) programme (for more about the project, see Bolte, Holbrook & Rauch (Eds.), 2012; PROFILES Newsletter, 2011) has been carried out in Slovenia for the last three years (2011/2012, 2012/2013 and 2013/2014 school years). During these years, the teachers were presented with many different components important for their development, planned on the basis of their needs and designed to guide teachers to reach ownership of the PROFILES ideas (more in Devetak et al., 2012). The major focus for the teachers was:

a) to learn how to design modules based on the 3-stage model: (1) a socio-scientific scenario, (2) IBSE (Inquiry-Based Science Education) and (3) decision-making (PROFILES Newsletter, 2011, p. 9);
b) to design modules in smaller groups with the help of a consultant, a member of the national team, and consequently be able to individually design modules;
c) to implement modules in the classroom, and
d) to measure the effects of the implementation on students' knowledge and motivation for learning science.

The Slovenian PROFILES team upgraded the learning modules for students' independent group work (teachers only guide students in the process of this collaborative learning) by following the principles of „active learning" (Devetak & Vogrinc, 2014, p. 9), which, for modules, also included guidelines for experiments undertaken by the students.

Three modules: two for general science lessons „Can I really be a whole orchestra?" and „Ouch, my head hurts. How can I help myself the quickest way?" and one for biology lesson „Should athletes undertake high altitude training?" were designed to meet the status of PROFILES modules (Holbrook, 2012, p. 7). In the paper only the aim and main points of the modules are presented so as to show how different content in science teaching can be presented to students within the PROFILES approach. Besides the module presentation, the main aim of the paper is teachers' reflection on the project cooperation and modules implementation from their TPD and on students.

Rationale and purpose

The purpose of the paper is to present (1) three modules with some experiments, (2) teachers' observation on how the students accepted the PROFILES approach, (3) teachers' opinion on the impact of the implementation on students' sustainability of knowledge, and (4) teachers' review of project cooperation and module designing on their professional development.

Opinions are mainly, where not stated differently, from the teachers, who are also the authors of this paper.

Teacher cooperation and project progress

Teacher decided to cooperate in the project based on a leaflet carrying the project description and aims which they received by e-mail in 2011. The important arguments persuading teachers to decide to participate were inquiry-based science teaching following the IBSE principle and learning about experiences from other European countries on this issue. Their main expectations were to gain knowledge and information on how to motivate students for learning and thus showing students why the content is important to be learned. Their prior experiences had been that students learn more if they are motivated and if they reach definitions and rules by themselves; but, in this project, a further dimension was how the motivational issue was connected with students' everyday living.

The teachers cooperated in different groups, assigned based on which subject they teach and a consultant was appointed to every group. In the first year (2011/2012) the teachers figured out how important it is to design the research work in the right manner and how to introduce content into a socio-scientific scenario. Also skills in communication and cooperation were enforced throughout the year. Of course, there were challenges in the teachers' participating (see more in the teachers' evaluation of the project part of the paper).

In the second year (2012/2013) their work in the project was more fluent and organized, due to their and other participants' previous experience. Besides that most modules were not designed from start, but were mainly upgrades of the previous year PROFILES modules. Revisions were made based on reflections of previous implementations in class. In the first and second year, all groups designed at least two, but usually three, modules.

The third year participation in the project was more on an individual basis. Some teachers decided to further develop modules and perform them in class, but also cooperation between teachers and consultants were established as teachers found it important to exchange information on their work and on students' responses to different approaches.

Many of the experiments included in the modules were already performed in class and, in the process of module designing, were integrated in it. Others were newly developed by a group of teachers while discussing the students' activities. Many ideas were generated and a selection had to be made based on the limitations of needed materials, or lab equipment accessibility and teaching time.

Three designed modules are presented.

Module 1 (general science): „Ouch, my head hurts. How can I help myself the quickest way?“

In the module students learn the basics of preparing solutions and their properties. It is developed for 12–years-old students, who are beginners in real independent research work in the Slovenian school system. For that reason the module is composed and designed a bit differently. Within the scope of three school hours, students are shown how to learn individually and how to individually prepare for research work. Skills of accurate reading and information searching are developed and competence for independent research enhanced. In introducing experiments, students are prepared

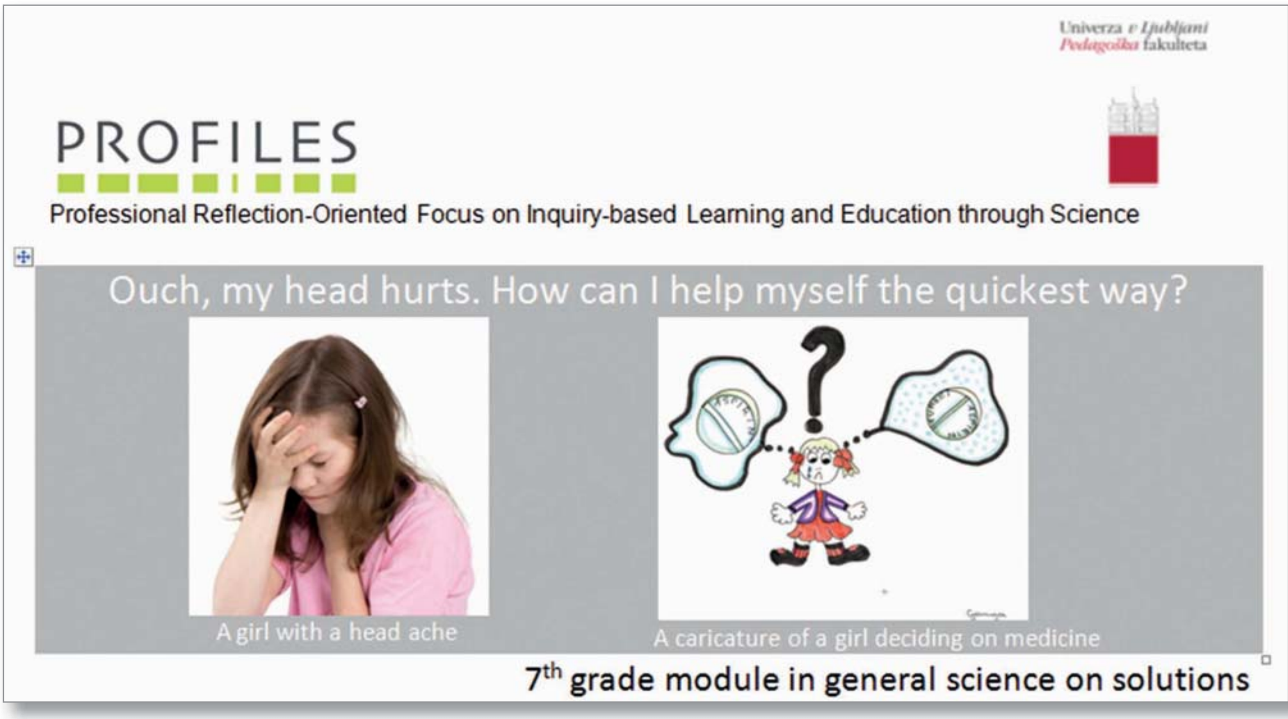


Figure 1. A part of the front page of the module „Ouch, my head hurts. How can I help myself the quickest way?"

step by step for independent experimenting. They learn how to properly read and understand instructions.

One of the experiments in the module is for students to research and determine whether the dissolving of a multivitamin effervescent tablet is dependent on the amount of carbon dioxide in the mineral water. Students compare the time of dissolving of the tablet in different waters with different carbon dioxide content (see Figure 2). They learn that an excessive amount of carbon dioxide slows down the dissolving of a tablet.

Module 2 (general science): „Can I really be a whole orchestra?"

Since experience from first year of PROFILES showed that younger (12-years-old) students had difficulties in working completely independently, we designed a module, where students independently upgrade their knowledge on the theory of sound, in addition to learning new concepts in traditional lessons.

So, in the three school hours of the module's duration, students gained theoretical knowledge of the subject. After learning new concepts they followed instructions on how to make musical instruments and they also tried to tune them. In the module, students planned the construction of drums, bells (with bottles, nails), a flute (made of reeds) and a simple guitar. Students used their knowledge of sound to demonstrate how the orchestra, composed of the whole class, could function (Figure 3).

Figure 2. 7th grade students of Primary school Ivana Babiča-Jagra Marezige, school year 2012/2013, author Tatjana D. Radivojević

Module 3 (biology): „Should athletes undertake high altitude training?“

The module is designed to address the structure and functioning of the respiratory tract. Basic tasks, functioning and structure are discussed. With more or less guided experimental work, students' define characteristics of the respiratory tract and determine its boundaries. By connecting personal experiences and literature reviews, they learn about the most frequent diseases and types of injuries. Knowledge is further upgraded by solving tasks, group discussions, planning and performing an experiment and reporting the results. At the end students find answers to all given questions regarding the title of the module. The module is planned for four learning hours.

Learning aims:

1. students understand the difference between lung and cellular respiration and their connection,
2. students understand the breathe in and breathe out mechanism (comparison with a simple model),
3. students learn the structure of lungs and the process of gas exchange and they connect that with the transport of gas to cells by the circulatory system, and
4. students learn causes and consequences of the most frequent illnesses of the respiratory organs, comprehend the negative influences of fine particles and toxic substances (smoking, asbestos, inhaling drugs, allergies and others), the danger of suffocation, the importance of prevention and first aid.

Competences developed: reading literacy, communication skills, skills of deciding and argumentation, ability to conduct research work, comprehending the respiratory tract mechanism, and prevention for healthy respiratory organs.

Students performed five experiments:

(1) Diffusion. A simple experiment and an animation of particles movement, show and enable students to develop the idea of how particles transfer from one side to the other, caused by differences in concentration. This characteristic of substances enables the exchange of carbon dioxide and oxygen in all phases of breathing within the lungs and at the cellular level.

(2) Body changes due to physical activity. Due to physical activity our body temperature and number of breaths increases. Measured facts are connected with the need and consumption of oxygen in cell respiration and the reasons for that.

(3) How do lungs function? Following given instructions, students make their own functioning model of a lung with a plastic bottle and balloons. Using the model, they test the breathing process and the functions of individual organs in that. They can also identify what happens, if we injure our thorax and the air breaks into the space between the ribs and lungs.

(4) What happens with breathed in air? How long does the candle burn in fresh air and in breathed out air? The measurements show that the burning time in the breathed out air is shorter. If we presume, that the oxygen enables burning, there is less of that gas (oxygen) in the breathed out air. The amount of oxygen in air is diminished within the lungs. But, of course, some of the oxygen stays in the breathed out air, because not all is transferred through the walls of the alveolar and capillaries in the lungs.

Figure 3. Finish of the module – orchestra; 7th grade students of Primary school Ivana Babiča-Jagra Marezige, school year 2012/2013, author Tatjana D. Radivojević

Module implementation evaluation

After three years, and implementation of at least six modules in class, teachers obtained some important observations and experience of the students' attitudes toward the PROFILES approach.

One of the teachers observed that, at module presentation, students get excited to do research and experiment. But they have difficulties in reading the instructions and undertaking independent work. This phase quickly transfers to another, when they discover that this kind of work expects a lot more of their individual engagement and involvement in thinking activities. But at the end, the most satisfied are the students who are more successful also in the classical way of learning. They usually express that this kind of work as more interesting, more relaxed, cooperative, and the gained knowledge is more coherent and sustainable. In the teachers' opinion, the PROFILES approach is very appropriate for the gifted students.

The other teacher observed that, with each module, students were more excited about the approach. More problems were detected by the students who are the poorer readers, since in the independently conducted work, it is very important to understand, find and select the information. Thus groups were formed in a purposive way (e.g. heterogeneous groups, musician in the group when the module about sound was used). They were also interested when activities were performed in other subjects and in science we achieved across the curriculum connections. But, as experiences of other teachers showed, students who actively participated and performed all the tasks, who were accurate in taking measurements, achieved all the aims of the module and their knowledge was better. Teachers also noticed that in tasks at the end of the specific module, students were very innovative and after finishing the module they tried to design their own similar experiments. And on a longer term they remembered the principles they learned. But on the other side, there were also students who took research learning as a game and they did not achieved good results on knowledge tests. The approach for them was just an easy way to get through the science classes.

Also other teachers that participated in the project stated, in a reflection questionnaire, given to them at the end of each year, that students' mostly accepted the PROFILES approach as an interesting way of learning. Mostly they were drawn to the issue in the presented scenario and were excited to do the experiments. But, as always, not all of them appraised it in the same manner. Mostly the better students, who had fewer difficulties in accomplishing the tasks, were more excited and gained more.

Teachers' evaluation of the project

After three years of cooperation, teachers' experience with the project cooperation and modules implementation were mixed. There were many gains and also some challenges that needed to be addressed.

In the first year, teachers needed to adjust to the group work. Nevertheless Slovenian teachers cooperate between themselves, usually at the school level, but there they faced the issue to cooperate on a wider level. Coordination of the group work and the dynamics within this was a great challenge. Usually things started smoothly, but after different opinions and issues to address appear, some members of the groups found it hard to be motivated in active participation, especially when living in different parts of Slovenia. But in these cases, the consultants were of a great help. Teachers, themselves, addressed this, mainly communicational boundary, by finding new ways of communication (internet networks, cloud offices) whenever co-members could not be reached in the neighbour office.

Quite a struggle was also the coordination of lesson content. In the Slovenian school system, the lessons timeline is not exactly defined; just the knowledge standards that need to be achieved are presented in the national curriculum of the specific school subject. So, individual teachers can autonomously plan their work throughout the school year. Since the project started after teachers' had already prepared their plans, this problem was another issue to be addressed.

The consultants were also an important link between the group members. As in class also between teachers there were ones who were more and others who were less motivated for work and difficulties in deadlines sometimes appeared. The consultant was the one who by each idea suggested revisions and pushed/motivated them when their enthusiasm was decreasing. So it is fair to say, they were their critical friend.

But the biggest issue, which is also a challenge for further work of academics and teachers' cooperation in joint project, is the administration and data collecting. Teachers struggled to collect all the needed and anticipated data. They needed to gain new knowledge on the issue and mostly the problem was how to present the data collecting to students' as an important part of their work. Students' mainly found all the data gathering techniques used by teachers to get the data about the modules implementation (i.e. questionnaires, interviews, observations…), as meaningless. So teachers' often doubted the validity of the results.

But on the other side, the positive effects of the project influenced the teachers' decisions to continue participating for the whole three years of the project duration and they will continue with this approach also after the project ends. Teachers gained new subject knowledge, new methods used in following their teaching and students' gains and learning strategies that are important for their professional development. Although meeting at the faculty took place after their school work, the lessons were of so great quality that they felt it worthwhile and the time flew by quickly. With the gained new knowledge, the project fulfilled their expectations – professional development, new ways of teaching, widened their horizons for further work, since new generations of students who are familiar with the modern ICT are being expected that will have to be taught how to read in detail, search information, select information and evaluate information.

One of the teachers said that she is very satisfied that she joined the project. She enhanced her self-confidence, because of the opportunity of equal cooperation with all the members of the team. With her that is usually quite a deficit since in her teaching environment, at a small school, she cannot compare or exchange experiences since she is the only one to teach many science subjects. And that is what brings the networking to its meaning – equal positions and giving each other support; teachers have more or less a need to communicate with others for peer exchange and also the relationship with the academics, usually not perceived as equal, is in quality networks treated at an equal level, which was also one of the objections that the national team was perceiving.

Conclusions

Teachers need continuous professional development to be able to emit the energy in class needed to motivate students to learn. Participating in the project is often a result of teachers' needs of progressing and in this particular project also the research working was a strong magnet. The rest of the activities, e.g. consultations and coordination, brought out also the need to get together and were an asset to fulfill the necessity of novelties and better quality.

The designed modules will be also implemented in the classroom by most teachers in the future. Of course adjustments and revisions will be made so as to adjust them to current students' needs and working environment. Further work can be expected to go into the direction of how to make the best of this approach in the classroom for the science gifted students. The Slovenian experience showed that, within the implementation of modules, gifted students gained the most.

Teachers' beliefs projects, organised like this one, enable the participants to advance in their professional field and consequently their modernization of teaching, in accordance with the changes that are taking place in all areas of our lives.

Further issues, which need to be addressed in the future and which are an open challenge in academic-teacher joint projects, are administration, data collecting and data analysis. Most teachers don't feel capable enough to perform these activities to be able to evaluate the outcomes of the innovation used in the classroom. Also, students are often unmotivated to participate in evaluation and because of that some teachers are not convinced of the validity of the results.

References

Bolte, C., Holbrook, J., & Rauch, F. (Eds.). (2012). *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project*. Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Devetak, I., & Vogrinc, J. (2014). The Slovenian PROFILES Model of Science Teachers' Professional Development. *PROFILES Newsletter, 5*, 9–13. Retrieved from: http://www.profiles-project.eu/res/Newsletters/PROFILES-Newsletter-5.pdf?1391067866 (15.06.2014).

Devetak, I., Ferk Savec, V., Glažar, S. A., Juriševič, M., Metljak, M., Kralj, B., Urbančič, M., Vogrinc, J. & Wissiak Grm, K. S. (2012). Slovenian reflection on the first year of the PROFILES project. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 145–147). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Devetak, I., Vogrinc, J., & Glažar, S. (2011). Guided active learning in chemistry modules used in the PROFILES in Slovenia. Science Education Research, Science Learning & Citizenship. [book of abstracts]. *European science education research, ESERA*, Lyon, p. 255.

Holbrook, J. (2012). Requirements of PROFILES Modules. *PROFILES Newsletter, 3*, 7–9. Retrieved from: http://www.profiles-project.eu/res/Newsletters/PROFILES-Newsletter_3.pdf?1355480383 (15.06.2014).

PROFILES Newsletter. (2011). Nr. 1. Retrieved from: http://www.profiles-project.eu/res/Newsletters/PROFILES-Newsletter-1_formatiert.pdf?1383911997 (15.06.2014).

5.12 The Experience of Spanish Teacher Trainees at UVa Developing Modules During Their CPD

Elena Charro, Susana Plaza, Esther Charro-Huerga & Ángela Gómez-Niño – School of Education, University of Valladolid, Spain

Introduction

In this work, a description of the courses (CPD) developed by the Spanish PROFILES group are shown. The courses have been implemented to promote IBSE strategies, where new modules, related with socio-scientific issues related to environmental and health topics, have been proposed.

The three rounds of the UVa CPD

The CPD programmes have been developed in the School of Education at University of Valladolid for three consecutive academic years (2011–12, 2012–13, 2013–14). The total number of pre-service teachers that participated was 64, the number of pre-service teachers that participated in each CPD varied in each academic year. In all cases, the total number of hours devoted to each CPD was 40, undertaken face to face.

Academic year 2011–12: During the first year of the project, only one CPD programme was carried out, for a duration of 40 hours and with 10 pre-service teachers from the Secondary School Teacher Masters in Chemistry and Physics. The period available for this course was November–December 2011.

Academic year 2012–13: In this academic year, 3 CPD programmes have been carried out, distributed as follows:

- The CPD developed during the previous academic year was repeated with 9 pre-service teachers belonging to the Secondary School Teacher Master in Chemistry and Physics. It was completed during November and December 2012.
- A new CPD was carried out for 6 pre-service teachers belonging to the Secondary School Teacher Master in Biology and Geology. It was completed during January and February 2013.
- In order to achieve a higher number of participants, a new CPD was developed for the last year for the Grade of Primary School Teacher students. In this, 25 pre-service primary school teachers attended the programme during September – November 2012. These participants are considered pre-service teachers, because they will be working in the next academic year.

*Academic year 2013–14***:** In the third round, 1 CPD have been carried out, distributed as follows:

- The CPD developed during the previous academic year was repeated with 14 pre-service teachers belonging to the Secondary School Teacher Master in Chemistry and Physics. It was completed during January and February 2014.

All the CPD programmes were similarly designed and this is described as follows:

1. The first part takes 5 hours of inquiry-based learning of science instruction and the relevance of stimulating intrinsic motivation of students for improving their science literacy. For this part, classical and new bibliography, including that published by some of the project members, is used. They do not need additional scientific background because they were usually science students (Grade of Chemistry, Physics, Biology or Geology) during the previous years.
2. In the next stage, pre-service teachers become familiar with several PROFILES modules, work with them in small groups (2–3 person). They implement some of the modules and report their outcomes to each other in the different groups and reflect on the experience. This process takes 10 hours.

The last part is devoted to discussions on this approach to the teaching and learning in the sciences and to reflect upon the experience of working with the modules. They then, working in groups, develop a module following the PROFILES guideline and the 3-stage format. They take into consideration the importance of choosing relevant approaches for their future students in order to stimulate their motivation. This part takes 25 hours. Additionally, some of them are able to implement a module in their 5 week period of practice in schools (5–10 additional hours).

In all the CPD programmes, pre-service and training teachers have developed PROFILES modules and some have been implemented in the classroom by the teachers. Additionally, as a result, several pre-service teachers decided to focus on their experience with developing and implementing PROFILES modules for their postgraduate studies and master dissertation.

The completed CPD programme showed its usefulness for the Secondary School Teacher Master for disseminating the philosophy of the project (Alvarez, Charro, Gómez-Niño, 2012; Eugenio, Charro, Gómez-Niño, 2012, Padilla et al., 2012).

References

Alvarez O., Charro E., & Gómez-Niño A. (2012). Adaption of teaching modules under PROFILES, as a tool for initial teacher training. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 153–155). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Eugenio M., Charro E., & Gómez-Niño A. (2012). Extending-Inquiry based science education to teacher training through the PROFILES Project: An experience. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education* *in Europe: Reflections from the PROFILES Project* (pp. 151–153). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

Padilla Y., Gago A., Roldán M., Urdiales C., Charro E., & Gómez-Niño A. (2012). Designing an IBSE module: a task for pre-service teacher training. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based Science Education in Europe: Reflections from the PROFILES Project* (pp. 157–159). Berlin: Freie Universität Berlin (Germany) / Klagenfurt: Alpen-Adria-Universität Klagenfurt (Austria).

5.13 The Blossoms of PROFILES in Karlstad

Shu-Nu Chang Rundgren – Department of Engineering and Chemical Sciences, Karlstad University, Sweden

Abstract

Based on the importance of inquiry- and context-based science education (IC-BaSE) in promoting students' learning interests and skills of inquiry and argumentation, the EU FP 7 project, PROFILES, has developed a 3-step teaching approach, with contextualization, de-contextualization and re-contextualization steps to share with science teachers. In the presentation of the science fair, the PROFILES group in Sweden presents five modules that the participating teachers have developed during their CPD programmes. A total of eight teachers from the Karlstad Municipality share with other participants their experiences from joining the PROFILES CPD programmes and the implementation of PROFILES teaching modules.

Inquiry- and context-based science education (IC-BaSE)

To enhance students' learning interests in the sciences, both inquiry-based science education (IBSE) (Yeomans, 2011; Banchi & Bell, 2008; Bulte, Westbroek, De Jong & Pilot, 2006) and context-based teaching have been proposed (Bennett, Lubben & Hogarth, 2007; King, 2012). In the EU FP7 project, PROFILES, a combination of IBSE and context-based teaching (education through science) has been proposed and developed as a PROFILES 3-stage model (Figure 1) to work with in-service teachers in promoting science teaching and learning with a focus of students' learning interests and skills of inquiry and argumentation, in addition to context-related scientific knowledge (Holbrook & Rannikmäe, 2010).

The importance of teachers' continuous professional development (CPD)

How teachers' professional development affects students' achievement has been presented by Yoon, Duncan, Lee, Scarloss & Shapley(2007), as shown in Figure 2. Teachers' professional development has shown a direct impact on students' achievement with more than 14 hours programme time in a cycle (Yoon, et al., 2007). According to Viellegas-Reimers (2003), teachers' professional growth could be defined as increased experiences, and at the same time, teachers need to examine/reflect upon their own teaching practices systematically in teachers' professional development programmes, for both in-service and pre-service teachers.

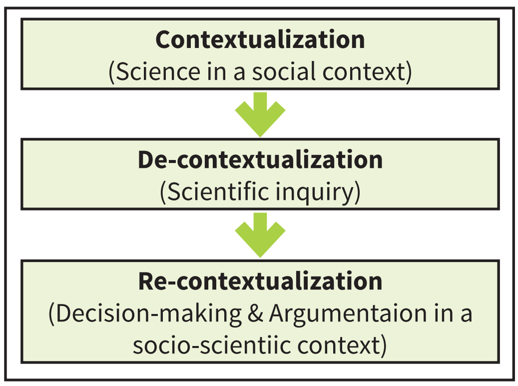


Figure 1. The PROFILES 3-stage approach (Holbrook & Rannikmäe, 2010).

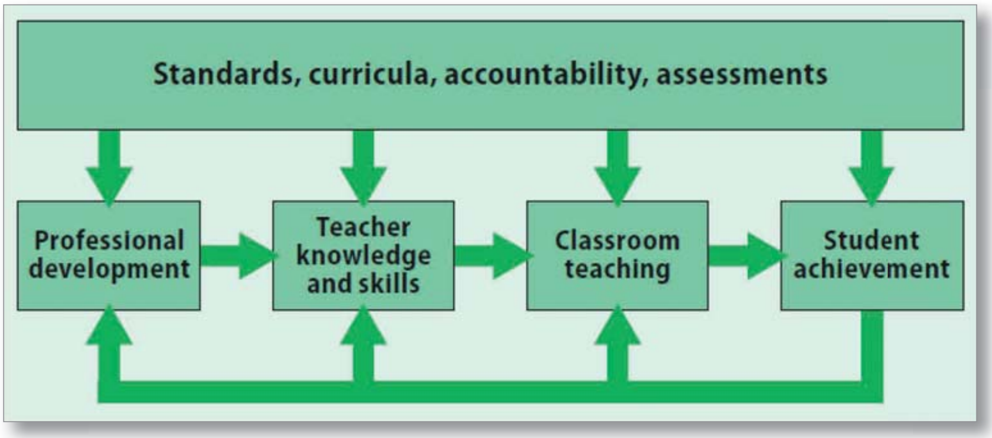


Figure 2. How professional development affects student achievement (cited from Yoon et al., 2007, p. 4)

Steps of CPD / Content in CPD workshops	**C**: context-based science education	**I**: inquiry-based science education	**A**: assessment of argumentation
Workshop 1 1. Lectures 2. Group reflections 3. Group work on developing PROFILES modules	X		
Workshop 2 1. Lectures 2. Group reflections 3. Group work of developing PROFILES modules		X	
Workshop 3 1. Lectures 2. Group reflections 3. Group work of developing PROFILES modules			X
Workshop 4 Finalizing teachers' development of PROFILES modules	X	X	X
Workshop 5 Teachers' presentation of the implementation outcomes concerning each of the PROFILES modules	X	X	X

Table 1. The CIA model for the PROFILES CPD programmes in Karlstad

Context	Students' age level	The developers (The teachers' names)
Is radiation from your mobile phone dangerous or not?	13–16	Åsa Koppfeldt*, Karin Varlund-Backlin* and Håkan Dahlin
Does breakfast influence your school achievements or not?	13–16	Emil Antonson*, Lennart Trillkott*, Henrik Skarman and Jonas Engstrand
Why do satellites not fall down?	10–13	Mia Toreld*, Sofia Tysklind Kling*, Stefan Nilsson and Kristina Karlstam
Should we drink orange juice or sweet drinks for lunch?	10–13	Åsa Florqvist* and Agneta Andersson
Which soap should we buy?	10–13	Marianne Johansson*, Madeleine Vestin, Sara Melcher, Linda Söderström, Sofia Järkeborn and Jenny Nedin

Note: The teachers with * are the one presenting the modules at the PROFILES conference in Berlin.

Table 2. The PROFILES modules developed by the teachers from Karlstad Municipality

In the sense of increased experiences, we think that both aspects concerning cognitive and skill domains are needed to be embraced. In other words, from the aspect of teachers' professional knowledge, pointed out by Shulman (Shulman, 1986; 1987), the cognitive and skill domains could be seen as knowledge of PCK and CK, as well as the related teaching practices.

Based on the importance of teachers' professional development for both in-service and pre-service teachers, continuous professional development (CPD) has been used specially for in-service teachers' professional development. In line with the philosophy of PROFILES, a 40-hour CPD programme has been organized to enhance inquiry- and context-based science teaching and learning. In the same vein as the PROFILES 3-stage approach, the CPD programme starts with a discussion on the importance and the notion of context-based science education (C), inquiry-based science education (I) and then dealing with assessment of argumentation (A). Therefore, we term the CPD model as CIA CPD model. The CIA model was composed of lectures, group reflections on the tensions explicitly and group work – in developing modules based on the PROFILES 3-stage approach (Table 1).

The participating teachers' PROFILES teaching modules in Karlstad

In the science fair, a total of 8 school teachers will join and share their PROFILES modules. The presented five modules are for students 10–13 years of age or for 13–16 years-old students (Table 2).

Acknowledgement

Firstly, I would like to acknowledge financial support from the EC PROFILES project and to thank Karlstad University for allowing the PROFILES CPD programmes to come true. Also, thanks to the Karlstad Municipality for providing time for the participating teachers' to join our CPD programmes. Especially, I want to thank the participating teachers for their feedback in every workshop in the PROFILES CPD programmes. In the end, it is also important to thank the collaborators. Maria Holm, Daniel Olsson, Torodd Lunde and Susanne Walan, without whom we could not have PROFILES CPD programmes blossoming in Karlstad.

References

Banchi, H., & Bell, R. (2008). The many levels of inquiry. *Science and Children, 46*(2), 26–29.

Bennett, J., Lubben, F., & Hogarth, S. (2007). Bringing science to life: A synthesis of the research evidence on the effects of context-based and sts approaches to science teaching. *Science Education , 91*(3), 347–370.

Bulte, A. M. W., Westbroek, H. B., de Jong, O., & Pilot, A. (2006). A research approach to designing chemistry education using authentic practices as contexts. *International Journal of Science Education, 28*(9), 1063–1086.

Holbrook, J., & Rannikmäe, M. (2010). Contextualisation, de-contextualisation, re-contextualisation – A science teaching approach to enhance meaningful learning for scientific literacy. In I. Eilks & B. Ralle (Eds.), *Contemporary science education* (pp. 69–82). Aachen, Germany: Shaker Verlag.

King, D. (2012). New perspectives on context-based chemistry education: Using a dialectical sociocultural approach to view teaching and learning. *Studies in Science Education, 48*(1), 51–87.

Shulman, L. S. (1986). Those who understand: knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Shulman, L. S. (1987). Knowledge and teaching: foundations of the new reform. *Harvard Educational Review, 57*(1), 1–22.

Villegas-Reimers, E. (2003). *Teacher professional development: an international review of the literature*. UNESCO: International Insitute for Educational Planning.

Yeomans, E. (2011). Inquiry-based learning – what is its role in an inspiring science education? In *Perspectives on education: Inquiry-based learning*. Wellcome trust, England. Retrieved from: http://www.wellcome.ac.uk/News/2012/News/WTVM054002.htm (11.01.2014).

Yoon, K. S., Duncan, T., Lee, S. W., Scarloss, B., & Shapley, K. L. (2007). Reviewing the Evidence on How Teacher Professional Development Affects Student Achievement. *Issues & Answers Report, REL 2007–No. 033* (p. 55). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance.

5.14 Magic Pictures in Inquiry-based Learning in Switzerland

Manuel Haselhofer, Peter Labudde & Miriam Herrmann – University of Applied Sciences and Arts Northwestern Switzerland, Switzerland

For the Science Fair and Workshop-Sessions, within the 2nd International PROFILES conference in Berlin, 25–27 August 2014, important landmarks of the PROFILES project, from the Swiss perspective, are presented as showcasing two aspects: on the one hand, posters provide an insight into the training of teachers and the work of stakeholders within PROFILES and, on the other hand, specifically developed teaching units of inquiry-based learning (IBL) are presented and offered for trial.

The posters demonstrate how the Swiss PROFILES team succeeded in providing training courses on IBL for practicing teachers. In this way, the teachers are to be encouraged to reflect on their instruction and, by doing so, develop it further in the sense of PROFILES (Reflection Oriented Focus). In general, teacher training is considered as highly important in Switzerland, which can be seen among others in the wide range of training opportunities for teachers and the financial resources available to this end. The cooperation with the Swiss Pedagogic Center Basel City (PZ.BS) is visualized as an example. It is one institution, among other Swiss organisations, which provides didactic and pedagogic services and training for teachers and for school management at all educational levels, and seems predestined for promoting the process of teacher ownership of IBL (See for example: http://www.ed-bs.ch/bildung/pzbs).

Moreover, the example of PZ.BS shows how the ideas of PROFILES can be integrated into existing teaching- and the school development project, SWISE (Swiss Science Education). In the large-scale project, SWiSE (2014), didactic experts in science and teachers from 60 so-called SWiSE schools are cooperating; the goals of SWiSE are, amongst others, to develop age-specific approaches to science for students in compulsory school, as well as to support teachers with or without a scientific background to reflect on their instruction and develop it further in a qualitative manner.

The training of experts and the synergetic distribution of PROFILES ideas are in close connection with the developed teaching units of IBL. Thus, great importance can be attached to the teaching material developed within PROFILES. For this reason, some practical examples are presented at the Science Fair and the Workshop-Session and are offered with the respective didactic materials. By means of the process of scientific learning, all examples claim to provide a concrete learning context, which is to lead to a more comprehensive understanding (e.g. gaining knowledge in natural sciences) and a critical involvement (e.g. collecting data) with the learning context on offer.

In the following, three of them are explained briefly.

1. Example: Within the training course “Know-How! Inquiry-based learning“, which was targeted at science teachers in secondary level I, the questions of “How many drops of water fit onto one coin?” was addressed (see: http://blogs.fhnw.ch/profiles/unterrichtseinheiten). Based on the presentation of a problem, the students are to comprehend the concept of determination of mean value and the idea of mean variation with the help of typical scientific methods and to critically test the gained insights. In groups, the students examine how many drops of water fit onto a coin. They create an examination plan which is then discussed in class before the experiments with drops of water and they specify the research question during the research process.

2. Example: The project SWiSE (2014) focuses on the development of instruction and schools. The core focus is laid on the teachers and continuous professional development. It is concerned with the development and dissemination of inquiry-based science teaching approaches in particular. At many of the 60 SWiSE schools, teachers worked on teaching units with a strong focus on inquiry-based learning, partly in cooperation with didactic experts in natural science. The teaching unit *battery* is presented as a typical example.

A chemistry teacher and a physics teacher at the secondary school, Frenke in Liestal/Switzerland, both taught the same 9th grade in chemistry and physics. Within SWiSE, they conducted an interdisciplinary project. At the outset, they introduced the topic “batteries”. The students already had previous knowledge of terms such as acids, bases, and metals in chemistry and of terms such as charge, current, and resistance in physics. The design and function of a battery, however, were not yet known. In the course of the project, the students completed the following tasks:

1. read up on the design and function of a battery,
2. build a battery that makes a light emitting diode glow (Figure 1),
3. keep a project journal during the work process,
4. write a report after completing the battery,
5. present and explain the battery to the class.

The tasks, framework conditions and assessment criteria were handed out to the class in writing (Broch & Hermann, 2013). 16 lessons of 45 minutes, spread over six weeks, were available for the entire project including introduction and presentation. Grades were issued, which, along with other grades from conventional written exams, were then counted into the final report grades for chemistry and physics.

3. Example: Within the Master Programme "Science Education", the lecturer, P. Labudde, worked on the topics of "practical work", "inquiry-based learning", and "undoing gender in science lessons". In her master thesis, a student, M. Herrmann, followed up on these topics.

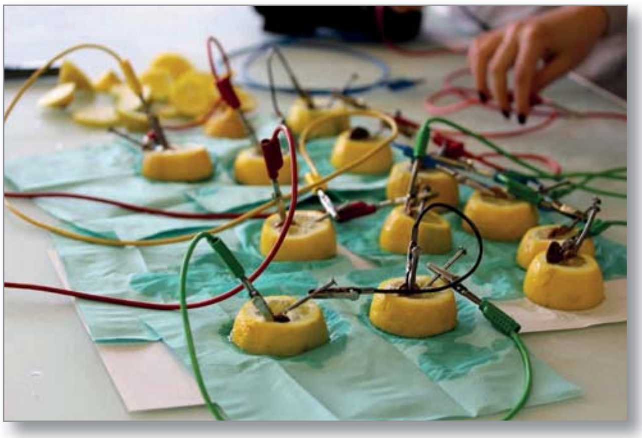


Figure 1. Battery that makes a light emitting diode glow

The interdisciplinary teaching unit "magic pictures" opens up three different approaches to the phenomenon of magnetism:

- experiment to create magic pictures (technological approach),
- perspectives for magic pictures (aesthetic approach) and
- physical-chemical explanation of the "labyrinth effect" and the "spiky structure" of the magic pictures (scientific approach).

Technological approach: The teacher can demonstrate parallels between the process of creating the pictures and the artistic process of technicians and artists: trying, optimizing, developing, and producing. The procedure of creating the magic pictures corresponds to the requirements of inquiry-based learning.

The author conceives the *aesthetic approach* to be the approach to magnetism via the beauty of the magic pictures, which enables a sensorial experience in natural sciences lessons. Moreover, the aesthetic approach is introduced in class via the description of a picture.

Scientific explanation: The scientific explanation for the *magic pictures*, as well as the material for teachers and students regarding this teaching unit are provided under the following link: https://blogs.fhnw.ch/profiles/.

The Swiss contribution to the Science Fair tries to express the following considerations. In Switzerland, we have succeeded in implementing the core concerns of PROFILES in various ways (two of the main goals of PROFILES Switzerland were i) the development and implementation of modules that focus on inquiry based learning (IBL), ii) the enhancement of teachers' ownership); the ideas of PROFILES were "injected" into existing projects or educational programmes. This creates positive conditions for pursuing the goals of SWiSE even after a project and for guaranteeing PROFILES sustainability.

References

Broch, R., & Hermann, M. (2013). *Eine einfache Batterie selber herstellen: eine Projektarbeit für Schülerinnen und Schüler der 9. Klasse* [Building a simple battery by oneself: a project for 9th grade students]. Liestal, Switzerland: Sekundarschule Frenke.

University of Applied Sciences and Arts Northwestern Switzerland, School for Teacher Education (2014). *PROFILES Schweiz: Unterrichtseinheiten [PROFILES SWITZERLAND: Teaching Units].* Retrieved from: http://blogs.fhnw.ch/profiles/unterrichtseinheiten (02.05.2014).

Herrmann, M. (2014a). *Physikunterricht zum Phänomen Magnetismus: Evaluationsstudie zu Interdisziplinarität und Gendergerechtigkeit [Physics instruction on the phenomenon of magnetism: evaluation study on interdisciplinarity and gender justice]*. Master thesis at the Zurich University of Teacher Education: Master Programme Didactics of Natural Sciences.

Herrmann, M. (2014b). Magische Bilder: Mit PROFILES das Phänomen Magnetismus mit ästhetischen Bildern sichtbar machen [Magic pictures: rendering the phenomenon of magnetism visible by means of aesthetic pictures]. *MNU* –

Der mathematische und naturwissenschaftliche Unterricht [MNU – Instruction in mathemathics and natural sciences] (in print).
SWiSE. (2014). *Swiss Science Edcuation*. Retrieved from: http://www.swise.ch (01.03.2014).

6 CONTRIBUTIONS OF OTHER EC-FUNDED PROJECTS AT THE SCIENCE EDUCATION FAIR

6.1 The Pathway to Inquiry-based Science Teaching

Franz X. Bogner – Centre of Math & Science Education (Z-MNU), Universität Bayreuth, Germany

Abstract

PATHWAY provides a frame toward a standard-based teaching science by inquiry by demonstrating potential ways to reduce existing constraints by disseminating exemplary introducing inquiry into science classrooms and also introducing professional development programmes. Additionally, a set of guidelines supported the educational community to further explore and exploit its unique benefits in science classrooms. Altogether, Pathway trained 10 053 *teachers by using the provided best practices in real school environments and providing and using the portal's materials appropriate for classroom use. More than 50% of all participating teachers were also involved in our extended evaluation process following the implementation of the inquiry activities in the classroom.*

The core of the PATHWAY exploitation strategy is the foundation of European Science Education Academy (ESEA) which focuses on science teacher professional development and its political support. The PATHWAY main outcomes (a series of guidelines, scenarios of practice, tools and show cases from the numerous PATHWAY teachers) are supposed to support participants to introduce innovative aspects in their school settings. The programme is offered in the form of webinars, interactive online sessions, residential courses as well as observations in PATHWAY schools.

PATHWAY included 25 partners from 15 countries:

1. UBT, University of Bayreuth, (DE), Coordinator
2. USH, University of Sheffield (UK)
3. BMUKK, Bundesministerium für Unterricht, Kunst und Kultur (AT)
4. UCAM, University of Cambridge (UK)
5. UB, University of Barcelona (SP)
6. AA, Ellinogermaniki Agogi (GR)
7. NFER, National Foundation for Educational Research (UK)
8. MUST, Museo Nazionale della Scienza e della Tecnologia Leonardo da Vinci (IT)
9. IASA, Institute of Accelerating Systems and Applications (GR)
10. KHLIM, Katholieke Hogeschool Limburg (BE)
11. CERN, European Organisation for Nuclear Research (CH)
12. CERTH, Centre for Research and Technology-Hellas (GR)
13. EUN, European Schoolnet (BE)
14. FRAUENHOFER-Gesellschaft zur Förderung der angewandten Forschung (DE)
15. DCU, Dublin City University (IRL)
16. HU, University of Helsinki (FI)
17. IEP, Institute of Educational Policy (GR)
18. ASPETE, School of Pedagogical and Technological Education (GR)
19. SHUMEN, University of Shumen (BG)
20. HUB, Humboldt-Universität zu Berlin (DE)
21. PHL, Pädagogische Hochschule Ludwigsburg (DE)
22. CCDC, Casa Corpului Didactic Cluj (RO)
23. EPS, European Physical Society (FR)
24. CITLE, Centre of Information Technologies and Leaning Environments (RU)
25. SHODOR, Shodor Education Foundation (USA)

Concept & main results

The teaching science by inquiry vision fortunately is a major science educational goal in Europe. PATHWAY as a single project supported this promotion towards a more widespread usage of inquiry-based science teaching in primary and secondary schools. PATHWAY proposed to move towards a standard-based approach that brings coordination, consistency and coherence to the improvement of science education. In this sense, the main project's objectives were the following:

1) A standard-based approach to teaching science by inquiry outlining instructional models to support teachers to organize effectively their instruction:

The determination of the underlying principles that govern the proposed standardization approach was based on the concepts and the theoretical approaches deriving from recent educational research in the field. The proposed approach imparted a deep understanding of content, taught prospective teachers appropriate ways to motivate young minds, especially with the suitable use of technology, and guided them in active and extended scientific inquiry, and instilled a knowledge of – and basic skills in using – effective teaching methods in the discipline. The PATHWAY framework gave more emphasis on continuously assessing student understanding, supporting a classroom community with cooperation, shared responsibility and respect and working with other teachers from other disciplines to enhance the aims of the school curriculum. Thus, PATHWAY demonstrated the pathway towards the generation of a common profile of the effective science teacher (the “practitioner of inquiry”) by proposing a methodology for inquiry-based educational practices in a commonly understandable way. Three main categories were involved: school-based activities and collaboration with both, science centres or museums as well as research centres.

2) To establish a group of practitioners of inquiry who share leading practices and influence policy development:

Teachers with specific “change management” competences are required to operate successfully as change agents in their schools facilitating the implementation of inquiry-based methods. To guarantee sustainability, a teacher community was gradually established and Best Practices were gathered according the PATHWAY guidelines. By this way, a series of exemplary teaching practices, resources and applications was put together that enables achieving scientific literacy, criteria for assessing and analysing students’ attainments in science and learning opportunities. It furthermore supported the community of practitioners by presenting effective teachers preparation and professional development programmes. The effective Educational Activities included: (i) Educational Activities that promote school – science centre and museum collaboration. (ii) Educational Activities that promote school – research centre collaboration. (iii) Effective Teachers Preparation and Professional Development Programme. A specific template allowed a categorisation of all proposed educational units with a major focus on: (a) how inquiry-based techniques can be introduced in the school practice, (b) how teachers can use the unique resources of science centres and museums in their lessons and (c) how effective forms of collaboration between researchers and the educational sector (formal and informal) could create valuable and meaningful learning experiences for all, fostering exploration, discovery, curiosity and collaboration.

3) To implement a large number of training activities that facilitates the effective introduction of inquiry to science classrooms and professional development programmes:

More than 10 000 science teachers throughout Europe were trained in the Pathway inquiry-based approach. Hereby, teacher communities had access to a unique collection of open educational resources (linked with the science curricula) that have proven their efficiency and efficacy in promoting inquiry-based education and that are expanding the limitations of classroom instruction. In order to guarantee a long term effect, the “European Science Education Academy” (ESEA) was established to promote inquiry-based teaching and learning in European schools and beyond. The vision behind the ESEA is supporting an international network of science centers, research centers, teacher communities, museums as well as policy makers, by specifically building upon the outcomes of PATHWAY.

4) To propose a methodology for designing, expressing and representing inquiry-based educational practices in a commonly understandable way:

Best Practice Educational Scenarios supported blocks of different scenarios identified as subject-domain independent "educational activities" that implemented a specific inquiry educational approach (for example Learning Cycle, Guided Research, Problem-Based Learning). Activities for teaching science by inquiry were organized in three main categories: school based activities, activities that promote school-science centre and museum collaboration and activities that promote school-research centre collaboration.

PATHWAY involved potential innovators in all project processes from the very start and keep them involved during the whole project lifetime. In total, 60 workshops have taken place in all partner countries involving 1 026 participants. At the end of the project, PATHWAY Summative Workshops were organised as one of the means to recapitulate on the experiences and lessons obtained from implementation of the training activities. Furthermore, the international training events contributed to the creation and support of an international community of practitioners.

In addition, partners have adopted multiple approaches to reach and involve the target audience in a Community of Practice. These include: Social networking tools, such as Facebook, Twitter, several localised web sites (in Germany, Spain and UK), active users were also gathered around science contests organised in several countries (e.g. Greece, Germany), face-to-face meetings and brainstorming activities were organised for the most interested and active people.

5) To further support the adoption of inquiry teaching by demonstrating ways to reduce the constraints presented by teachers and school management:

PATHWAY deployed a series of methods of effectively involving teachers in the inquiry instruction. In order to fully realize the potential of inquiry-based education, PATHWAY addressed all potential negative preconceptions adequately. The task at hand was to manage allowing teachers to realize the potential of the IBSE opportunity, take ownership by contribution and maximize the output. PATHWAY included institutions with significant expertise in designing effective professional development programmes. In order to diffuse IBSE across Europe, a large number of teachers training activities was implemented that facilitated the effective introduction of inquiry to science classrooms and professional development programmes. During the project implementation, teacher communities had access to a unique collection of open educational resources (linked with the science curricula) that had proven their efficiency and efficacy in promoting inquiry-based education and that were expanding the limitations of classroom instruction. Thus, PATHWAY brought together a network of educational communities, science centres and museums and research centres in order to act as the pilot group for the project activities. With this operation, PATHWAY managed to reach thousands of science in-service and pre-service teachers and students, in the belief that the adoption of inquiry methodologies will help grow deeper thinking and more aware citizens.

6) To deliver a set of guidelines for the educational community to further explore and exploit the unique benefits of IBSE:

PATHWAY asked for knowledge areas integration, effective and closes cross-institutional collaboration, and organizational change in the field of science education. This effort was documented analytically and systematically in "The Pathway to Inquiry-based Science Education". The main objective of the work was to generate a structured set of recommendations and that formed a pan European roadmap for IBSE to sustain the development/deployment of science educational methods and content services that supported the access and expanded the reuse of it.

The following figure shows the impact of the PATHWAY training activities validated in an overall analysis: For clustering and networking, PATHWAY developed a structure and mechanisms to disseminate the work and to highlight the collaborative working links. A specific dissemination strategy supported the exploitation and contributed to its sustainability. For example, PATHWAY promoted the project's results with oral presentations in conferences like ESERA-2013, eKNOW-2013, NTSDE-2014. A PATHWAY website (www.pathway-project.eu) provided guidance, offered resources and forums for exchange of information. The website acted – and still does – as an online reference point and makes four key areas accessible: (i) Inquiry Activities for Schools, (ii) Connecting Schools & Science Centres, (iii) Connecting Schools with Scientific Research, (iv) Teacher's Professional Development. Besides the provided information on the internet, the project members developed and distributed printed dissemination material, which included posters, flyers, bookmark, newsletter as well as user guides and support materials for the implementation of inquiry-based techniques in everyday school practice. A final conference on Inquiry-based Science Education with five invited keynote experts from Europe and the US gave a balanced platform to involve teachers, scientists, stakeholders and policy makers about recent aspects in the field.

7) To systematic validate the proposed approaches and activities in order to identify their impact in terms of the effectiveness and efficiency:

The PATHWAY validation offered a framework to identify their impact in terms of the effectiveness and efficiency by collecting quantitative and qualitative feedback. To allow for in-depth analysis of the impact of activities, the validation was carried out around each workshop/activity at different times and in four steps: general teacher information, pre and post knowledge questionnaire and long-term impact questionnaire. A set of questionnaires obtained feedback from the workshops' participants have been designed as well as the protocol to obtain this information. The questionnaires have undergone extensive revision to ensure both the comprehension from the participants as well as to guarantee they will provide enough data to evaluate the impact of the PATHWAY workshops.

Conclusions

The main conclusions of the project are the following: (1) The participation in PATHWAY increases the teachers' knowledge base about IBSME as well as their attitude towards implementing these methodologies with their students and diffusing the practices among their fellow teachers. (2) The relative scarcity of pre-event knowledge on the characteristics of IBSME methodologies is a good indicator for the necessity of projects like PATHWAY. (3) Pre-service teachers welcomed PATHWAY events as an opportunity for learning about and also experiencing and practicing IBSE. (4) Effects of the event type on the teachers' responses are found, including the use of ICT for dealing with differentiated groups of students. (5) The vast amount of detailed data available for individual event types opens up the possibility to perform detailed inter-event type analysis for a large number of topics considered in the questionnaires. (6) The teachers demanded more training time, as well as including further information about the potential use of ICT. (7) Teachers were quite pleased with the content of the training, even those teachers who already had some knowledge of IBSE. (8) Teachers appreciated the possibility to take home practical and usable class-materials. (9) The participants have shown a commitment to implementing the action plans developed during the events and many have started deploying them. (10) The use of research-based instructional strategies has been shown to result in changes in teachers' practices. (11) A evaluation exercise has allowed to illustrating the improvement's persistence made in the understanding of IBSE. (12) The evaluation data can be used as a guide for the organisation of teacher training courses, and a simulation exercise showing one of many possibilities to do this.

A major objective of PATHWAY was to promote and enhance the application of active T&L methodologies in the school, in particular IBSE. The seeds have been planted and have been shown to be already sprouting, and some areas for continuing efforts in teacher training and development as well as teachers' interactions and exchanges of resources have been earmarked. The relative scarcity of pre-event knowledge on the characteristics of IBSE methodologies is a good indicator for the necessity of projects like PATHWAY. In fact, many pre-service teachers explicitly welcomed this PATHWAY event as an opportunity for learning about and also experiencing and practicing IBSE themselves. The teachers demanded more training time, as well as including further information about related European projects and also on the use of ICT. And, in particular, teachers appreciated the possibility to take home practical and usable class-materials. The added value of this EU project encompasses the amount and origin of trainees, the diversity of trainees formal and non-formal working areas and educational levels, the large amount of training events delivering various formats and approaches, the quantity and quality of the pedagogical materials and methodologies that have been tested successfully, and positive response and enthusiasm from all stakeholders involved. The success of PATHWAY is empirically attested by the data provided, which is detailed in Figure 1.

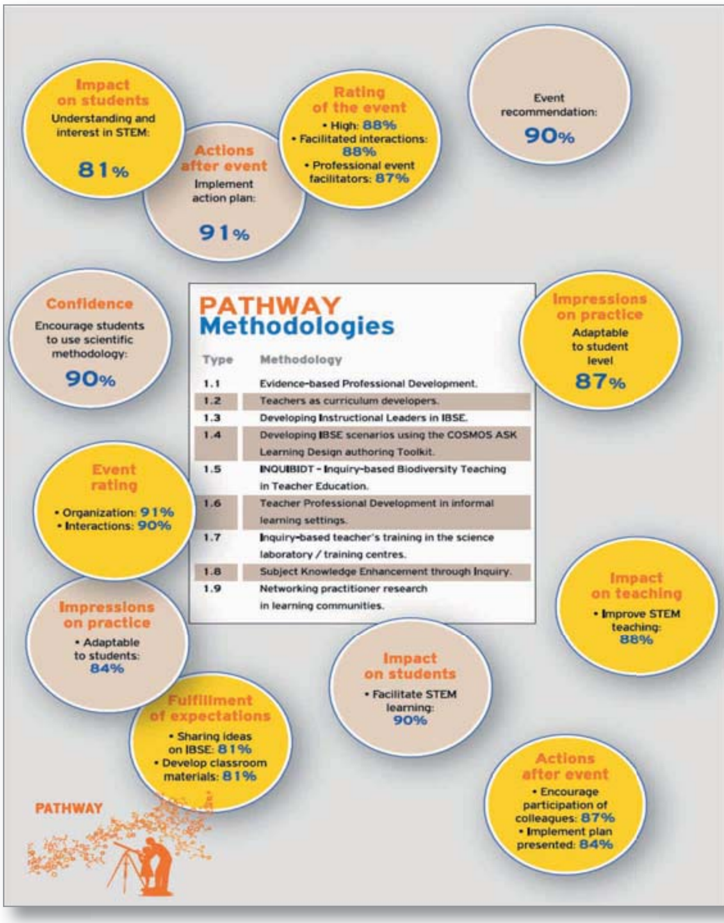


Figure 1. PATHWAY Methodologies

6.2 MARine Litter in Europe Seas: Social AwarenesS and CO-Responsibility

Doriana Calilli & Mara Di Berardo – Province of Teramo, Italy
Joana M. Veiga – Coastal & Marine Union (EUCC), Netherlands
Thomais Vlachogianni & Iro Alampei – Mediterranean Information Office for Environment, Culture and Sustainable Development (MIO-ECSDE), Greece
Sabine Pahl & Bonny L. Hartley – Plymouth University, School of Psychology, United Kingdom
Richard C. Thompson – Plymouth University, School of Marine Science and Engineering, United Kingdom
Kathrin Kopke & Thomas K. Doyle – Coastal & Marine Research Centre, University College Cork, Ireland
Thomas Maes & Eva Garnacho – Centre for Environment, Fisheries & Aquaculture (Cefas), United Kingdom
Demetra L. Orthodoxou & Xenia I. Loizidou – ISOTECH Ltd Environmental Research and Consultancy, Cyprus

Abstract

Marine litter is a complex and multi-dimensional problem, where responsibilities are often unclear and the burden of costs unequally divided within society. Although there are major economic and environmental impacts there is no simple solution in sight. In the last few years, the topic has gained major attention and momentum at European level. Marine litter is one of the eleven descriptors within the Marine Strategy Framework Directive and several projects have been funded to improve the understanding of associated processes and implications but also to promote and facilitate the coordination of efforts of

Member States towards effective solutions.
MARLISCO - MARine Litter in Europe Seas: Social AwarenesS and CO-Responsibility is a FP7 – Science in Society project (2012–2015), involving a diverse consortium of entities and is implemented in 15 European countries. It seeks to raise societal awareness, trigger co-responsibility across the different sectors and facilitate dialogue between the different actors on both the problems and the potential solutions regarding marine litter.
The project developed offers a series of tools and mechanisms to support and address some of the barriers that seem to be hindering a more effective response from society, such as lack of awareness and prevailing perceptions and attitudes of different stakeholders regarding marine litter with over 3 500 respondents. The project provides information and facts on the ML issue; a data-base of 72 examples of practices and initiatives; national forums in 12 partner countries, involving representatives from key sectors and the wider public to discuss and develop solutions; a European video contest targeting school students, which directly engaged over 2 000 European youngsters; a series of awareness-raising activities and innovative educational tools in several European languages, implemented and disseminated in 15 countries.
Overall, MARLISCO is about halfway through its programme of work. Already, levels of engagement of various stakeholders including scientists, marine practitioners, educationalists and the general public have been outstanding. In conjunction with the political impetus created by European Directives, MARLISCO is building up momentum and helping to address some of the barriers that seem to be hindering a more effective response from society on the issue of marine litter. The products, experiences and lessons-learned produced in MARLISCO are a valuable legacy that have the potential to be adapted and transferred elsewhere.

MARLISCO project description

MARLISCO, MARine Litter in Europe Seas: Social AwarenesS and CO-Responsibility (Figure 1, www.marlisco.eu), is a European Union 7th Framework Programme – Science in Society Project (June 2012 – May 2015) assembling a multidisciplinary and diverse group of entities seeking to raise public awareness, trigger co-responsibility across the different sectors and facilitate dialogue between the different actors on both the problems and the potential solutions related to Marine Litter (ML).

Figure 1. The MARLISCO logo

The project focuses on developing, implementing and evaluating mechanisms to better understand and communicate the problem in its environmental and social dimensions, promoting and encouraging society to define a more informed collective vision and actively engaging and empowering stakeholders to work towards concerted actions to address this complex issue.

The project has entered the last year of its programme of work but the levels of engagement obtained so far are already outstanding (Veiga et al., 2014, manuscript submitted).

MARLISCO incorporates a set of activities (see Figure 2), including a scoping study of the presence of ML in the marine environment and regional seas, methods for monitoring and assessment, and policies that might be applied to mitigate its impact (Work Package 1); a collection of good practices from all partner countries for the reduction of ML; an assessment of the prevailing perceptions and attitudes of different stakeholders regarding ML across Europe (WP2); national forums in 12 European countries, involving key stakeholders, relevant experts representating the industry sector, academia and the wider public (WP4); a European video contest for school students (WP5); a wealth of awareness-raising and educational activities and innovative tools targeting different audiences, including a problem-solving online “serious game” for youngsters and an educational pack accompanied by an e-learning course for educators; diversified, tailor-made national activities aiming to raise public awareness, including exhibitions in 15 partner countries (WP6); a project website development and management (WP3, www.marlisco.eu; Mossbauer, 2013) and coordination activities to define a project management plan (Santonocito, 2012), to manage the project internal communication (Di Berardo, 2012) and EC reporting (WP7).

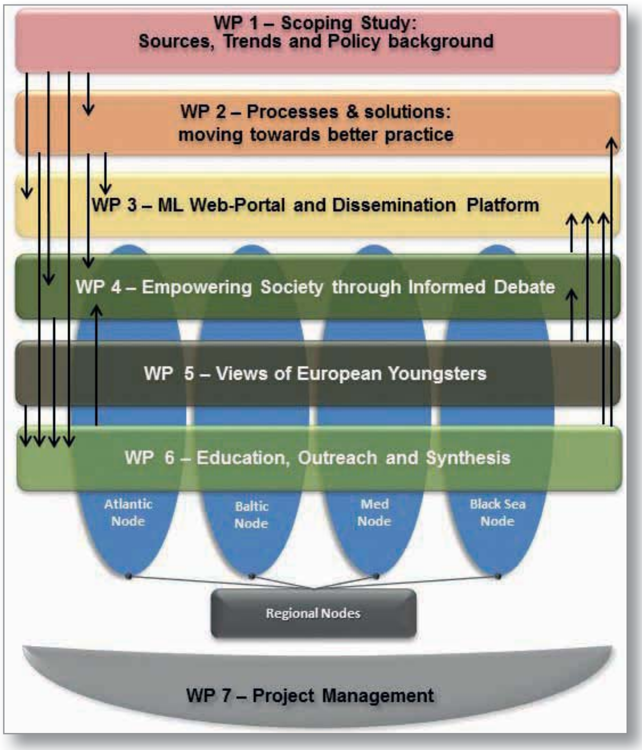


Figure 2. MARLISCO project structure and WPs integration

MARLISCO has a wide geographic coverage, with 20 partners from 15 countries, implementing activities in the four European Regional Seas: North-East Atlantic, Baltic Sea, Mediterranean Sea and Black Sea. The consortium composition (Table 1) is very diverse and includes regional and local authorities, research institutes and academia, environmental associations, industries and multimedia companies.

Fifteen of these organisations are responsible for implementing a set of national activities in their countries (Figure 3) and therefore MARLISCO covers 14 EU Member States and Turkey, and benefits from the inclusion of three associations from the plastic industry, representing plastic producers, converters and recyclers throughout Europe.

One of the initial activities of MARLISCO was to set a clear picture regarding ML in each of the European Regional Seas (WP1). WP1 included a review on distribution, quantities and types, sources, and impacts of ML (Kershaw, Hartley, Garnacho & Thompson 2013b); a summary of current methods of monitoring and assessment for ML (Maes & Garnacho, 2013); a review of existing policies that may be applied to mitigate the impact of ML (Kershaw et al., 2013a). This activity contributed to MARLISCO's general efforts towards a better understanding of the science-society nexus and translate research-based knowledge into action by providing material to define key topics and facts for national forums, raising awareness and educational activities.

MARLISCO's "Processes and solutions – moving towards better practices" WP2 aimed to better understand how society perceives the impacts, implications and responsibilities associated with the issue of ML and to identify some possible barriers that may be hindering more effective solutions. On the other hand, it intended to evaluate and bring to light initiatives and practices that are already in place, to demonstrate and facilitate the process of moving towards solutions. An interesting part of MARLISCO is a self-assessment approach, in which most of the national engagement and awareness activities are evaluated in terms of their impact on the individuals targeted.

To assess societal perceptions about ML, MARLISCO developed and conducted an extensive European-wide survey of societal awareness and perceptions about ML to examine individuals' understanding of the quantity, location, causes and consequences of ML, perceived risk and responsibility, and behavioural intentions to engage in solutions (Hartley, 2013). The survey was launched in the 15 coastal countries covered by the project and targeted key sectors, including the production industry, retailers, the coastal and marine industry, waste management, government and policy makers, environmental organisations, the media, the education sector and the general public. More than 3 500 respondents completed the survey, and results will enable better understanding of the barriers and opportunities in understanding this issue and engaging in effective solutions (Hartley, Pohl & Thompson, 2014, in preparation). This baseline survey will be followed up with a second perceptions survey in the final year of the project.

Regarding the evaluation of impacts of educational and engagement activities, MARLISCO is assessing whether and how each of the project's relevant activities might change people's understanding, attitudes and possibly their behaviour. Impact surveys have, or will be applied to participants involved in the national forums, Video Competition, national exhibitions and E-learning course to accompany pedagogical resources for educators.

In order to enhance co-responsibility across the different sectors of society, foster synergies between policies and key actors, and demonstrate that it is possible to move towards better practices and effective actions, MARLISCO has identified and compiled a series of examples of initiatives and practices from all the involved countries and elsewhere. A total of 72 practices (Orthodoxou, Loizidou & Loizides, 2013a), implemented by a range of stakeholder groups across the four European Regional Seas and elsewhere, have been collected, analysed and evaluated in terms of their effectiveness, sustainability (environmentally, economically and socially) and potential to be replicated. The practices have been made publically available in a data-base within the web-portal and searchable through a series of criteria (Orthodoxou, Mossbauer & Loizidou, 2013b). Complementing the web-based database, a Guide for Reducing Marine Litter provides additional information on how to turn these practices into action.

One of the key activities of MARLISCO is the development of national platforms (fora) for structured dialogue between the key stakeholders, relevant experts and the general public on the topic of *'Marine litter: developing solutions together'* (WP4). The fora have for objective to provide the participants[1] with the necessary scientific information in a readily accessible format and to actively engage them in dialogue. A common format for 12 national events to be implemented across European countries was designed (Doyle, 2013), trialled and subsequently successfully applied at the Irish National Forum held in April 2014. The developed format was modelled on participatory methodology developed for the MARGOV fora (Vasconcelos & Caser, 2012) and some characteristics are: use of a *Running Order*; on-line webcasting for a wide audience participation; interactive activities for all participants; an animated short documentary on *Sources and Impacts of Marine Litter*[2]; 'venue teams' (invited participants present at the event) and remote 'satellite teams' (online participants); a consensus approach for team working; a vote for the most effective and implementable actions proposed by the participants. The outcomes of each 12 national events and for all four regional seas will be organized in a final document.

MARLISCO foresaw a specific activity for engaging youngsters – a video competition targeting students in 14 of the countries covered by the project. The contest was implemented under a common framework (Veiga, 2013) and encouraged the students to develop short videos about the issue of ML. Overall 380 videos were submitted to the MARLISCO Video Contest, reflecting the active participation of over 2 000 youngsters across Europe that were directly involved in the making of these videos. National juries were set up in the 14 countries to select the best national video and other categories, together with "public voting" on *Youtube* and dissemination throughout social networks, reaching 1 000 "views" within the first week. A final compilation of the 14 national videos has been produced, with English subtitles and featuring an interactive menu that allows the user to choose the videos and view a short video introduction showcasing the national winners[3]. This "teaser" was premiered during the plenary session of the 7th European Maritime Day Ceremony (EMDC) in Bremen, Germany, a high-level stakeholder event organised by the European Commission. Eighty young people in total, from 13 different countries in Europe, received public recognition at the EMDC and took part in a two-day joint, intercultural and facilitated programme organised by MARLISCO.

[1] Such as fisheries, local authorities, port companies, representatives from tourism and recreation and NGO's, industry representatives.

[2] It's been specifically developed for all MARLISCO fora and premiered at the Irish event.

[3] www.marlisco.eu/Winner_Video_Compilation.en.html

Consortium Member	Country	Type
Provincia di Teramo (Lead Partner)	Italy	Regional Authority
Coastal and Marine Union, Netherlands	Netherlands	Environmental NGO and Network
Centre for Environment, Fisheries and Aquaculture Science	United Kingdom	Government Agency for Marine Science
Plymouth University	United Kingdom	University
European Plastics Converters	Belgium	Association of Plastic Industries
European Plastics Recyclers	Belgium	Association of Plastic Recyclers
MerTerre	France	Environmental NGO
Regionalni Razvojni Center Koper	Slovenia	Regional Development Centre
University College Cork, National University of Ireland	Ireland	University
Mare Nostrum	Romania	Environmental NGO
Die Küsten Union Deutschland	Germany	Environmental NGO
IsoTech LtD	Cyprus	Environmental Consultancy
Union of Bulgarian Black Sea Local Authorities	Bulgaria	Association of Local Authorities
Plastics Europe AISBL	Belgium	Association of Plastic Industries
Universidade Nova de Lisboa	Portugal	University
Mediterranean Information Office for Environment, Culture and Sustainable Development	Greece	Federation of Environmental NGOs
Turkish Marine Research Foundation	Turkey	Research Institute
Kommunernes Internationale Miljøorganisation	Denmark	Environmental Association of Municipalities
Honky Tonk Film	France	Multimedia Company
Media Tools	France	Multimedia Company

Table 1. The MARLISCO Consortium

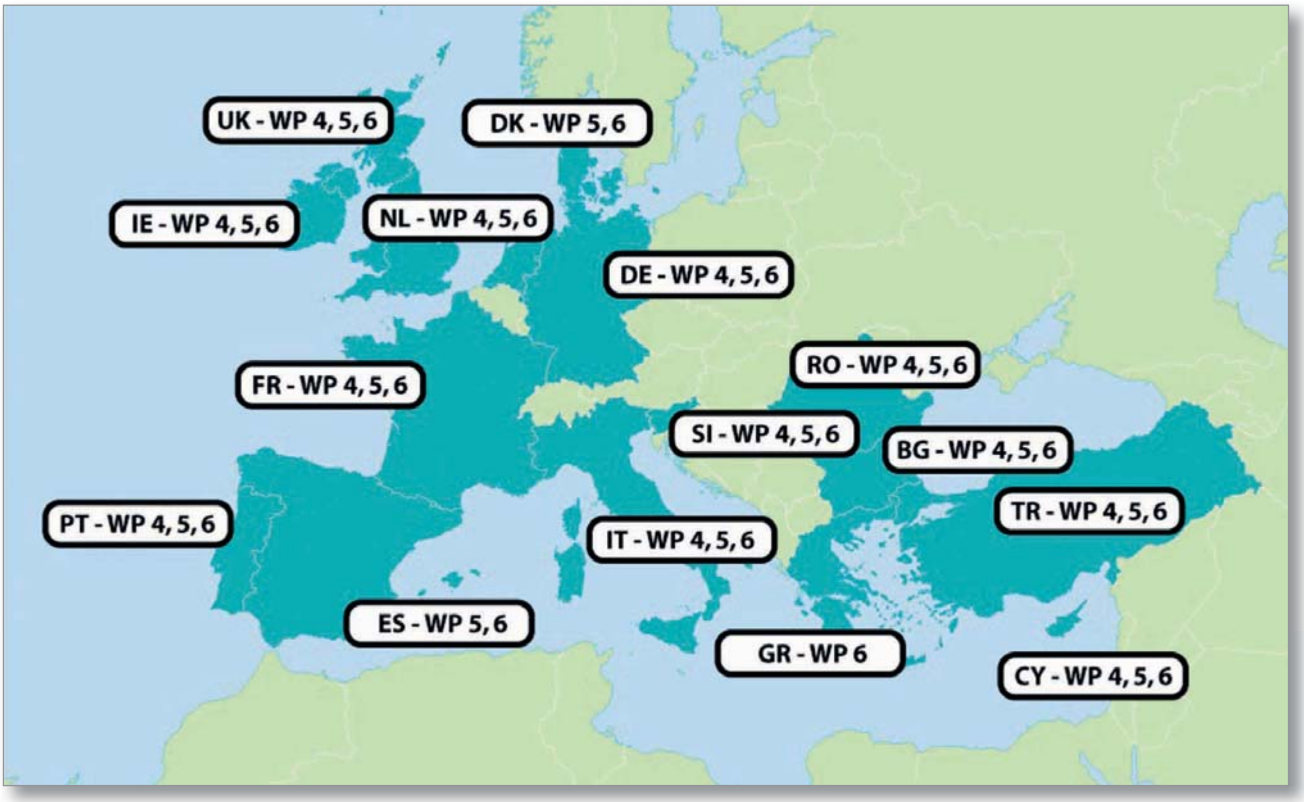


Figure 3. MARLISCO project and WPs geographic coverage

MARLISCO has undertaken the development of a diversified set of awareness-raising activities and educational tools, specifically an educational pack, an exhibition and a "serious game".

The educational pack, which is available in multiple European languages and is entitled "Know, Feel, Act to Stop Marine Litter", has been developed to address the current lack of pedagogical material on the issue of marine litter. It consists of 17 different activities, has a holistic approach, targets students of secondary level of education, and is designed in a flexible and adaptable format to be used either in formal education settings or non formal ones. This material is being complemented by an asynchronous e-learning course, targeted at European educators from the partners' countries, on how to apply this material (Alampei, 2013a).

An attractive and engaging exhibition was designed (Alampei, 2013b), aiming to enhance the understanding of the sources, implications, impacts and potential solutions for ML in the general public, adapted to both regional and national contexts and translated into national languages. This exhibition has been designed to allow easy transportation, set-up indoors or outdoors, and has been travelling within the 15 involved countries.

In a fruitful collaboration, multimedia and communications experts and scientists have developed an innovative interactive web-based, "serious game" for youngsters: it integrates effective problem-solving episodes with different characters representing key sectors with responsibility around the issue (e.g. a fisher, beach-user, land-fill manager, etc.).

Last but not least, a series of brochures is planned, tailored for specific stakeholder groups from different sectors[4], aiming to highlight their role and possible scope of action within their respective sector. A series of other national activities, workshops, festivals and beach clean-ups are used to complement the national exhibitions and act as channels to promote these tools (Alampei, 2013c).

Finally, the challenges, experiences and lessons learned from working on the science-society interface will be highlighted and consolidated in a

[4] e.g. industry, tourism sector, maritime sector, regional, national and local authorities, and civil society.

project synthesis report, providing further insight on fundamental opportunities and barriers for improving science-society communication, in order to encourage informed decisions, responsible behaviours and sustainable actions.

Outlook & reflection

The MARLISCO project represents an important step in understanding and addressing the ML problem by engaging society and promoting co-responsibility, motivation and opportunity for action. The various WP activities, from research, data collection and analysis of good practice to participatory and communication tools and actions, highlight how ML requires a combination of approaches to successfully reach different target audiences, generate co-responsibility across the different sectors and facilitate dialogue for solutions.

1) Basis for understanding barriers and evaluating ML interventions effectively

WP1 & 2 analysis and outputs scoping ML knowledge , social perception and attitudes helped the Consortium to better define WP4, WP5 and WP6 objectives, activities and design methods. Project outputs are publicly available at the MARLISCO portal (www.marlisco.eu) and can help other projects and institutions to translate research-based knowledge into actions, generate new solutions and actions, and give a base for the more in-depth comprehension of key actors, specificities and/or priorities. The outcomes from WPs 1 and 2, and new outcomes on science-in-society interactions that will be generated in the final year of the project, can be considered as a starting point for new studies.

2) Targeting and engaging of different stakeholders, triggering or strengthening long-lasting networks and processes

The European dimension of the project strengthens MARLISCO's effects because the activities are simultaneously carried out in various countries, targeting different layers of society, generating European-wide awareness and discussion, which is further amplified by the current political impetus set by certain European Directives (e.g. MSFD). Furthermore, its activities create an empirical legacy that helps long-lasting network creation on a national and cross-national level (e.g. a National Association integrating different key entities has been formally established in Portugal, specifically to help addressing this issue, which is in part due to MARLISCO stakeholder engagement activities). Finally, several partners have since then discussed national or European proposals with contacts made to further elaborate on the achievements of MARLISCO.

As for decision-makers and ML stakeholders, the national fora intend to take the process a step further and have been designed not only to clearly inform the participants but offer them a chance to propose, discuss constructively and prioritise potential and viable solutions that may contribute to reducing marine litter. The first forum in Ireland produced 20 ML reduction solutions and enabled mutual learning between participants of the event. Furthermore, another aim of this process is to facilitate the establishment or strengthening existing national and regional working groups, while supporting the national processes triggered by the implementation of the MSFD and other European and national policies on marine litter and waste management. Decision-makers and stakeholders are also benefiting from the MARLISCO web-database of good practices and initiatives, which is already referenced by several other national and transboundary initiatives and stakeholders.

3) Project outputs for future use and application with target audiences

All the public project outputs and tools will be available in the MARLISCO website, which will be kept online for at least two years after the project conclusion. These include public reports, educational resources, and models for implementing successful engagement activities. The educational products, experiences and outcomes from national activities, as well as reflections and lessons-learned produced in MARLISCO are a valuable legacy that have the potential to be adapted and transferred elsewhere. There has been already interest from countries originally not covered by MARLISCO to use and adapt some of the products developed by MARLISCO, including Sweden and some Middle East/North African countries.

As for youngsters and educators, the project aims at reaching a multiplication effect in changing attitudes, motivations and intentions. Youngsters can be powerful agents of change in society, not only because they represent the next generation of decision-makers and consumers but because it is known that children often directly influence the behaviour of their close family and peers. MARLISCO dedicated considerable resources to specifically engage this layer of society, not only with attractive and engaging tools like art workshops, the video contest and "serious game" but by providing multi-lingual educational material that can be used by educators. The video contest proved to be very successful in terms of direct participation and the videos themselves have the potential to reach a more vast number of people.

By developing, implementing, and evaluating mechanisms to better understand and communicate the problem, MARLISCO is addressing some of the barriers that seem to hinder a more effective response from society to this problem. In conjunction with the political impetus created by European Directives and their national implementation, MARLISCO is building-up momentum, encouraging and empowering the different sectors of society to take their share of responsibility and jointly work together to address the complex issue of marine litter.

MARLISCO has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no [289042]. The views and opinions expressed in this publication reflect the authors' view and the European Union is not liable for any use that may be made of the information contained therein.

References

Alampei, I. (2013a). MARLISCO D6.5 Program for training session. August, 01. MARLISCO Project deliverable. Security: Restricted to other PP.

Alampei, I. (2013b). MARLISCO D.6.2 Concept for basis of national exhibition, in English. July, 16. MARLISCO Project Deliverable. Security: Restricted to other PP.

Alampei, I. (2013c). MARLISCO D.6.3 Plan on national educative activities to be conducted in the different regional nodes. July, 26. MARLISCO Project Deliverable. Security: Restricted to other PP.

Di Berardo, M. (2012). MARLISCO D7.3 Online Project Management System (OPMS). November, 13. MARLISCO Project Deliverable. Security: Confidential.

Doyle, T. K. (2013). MARLISCO D4.1 Plan of action from each NP and the strategy for each forum events, based on a template. July, 05. MARLISCO Project Deliverable. Security: Confidential.

Hartley, B. (2013). MARLISCO D2.1 Baseline evaluation of stakeholders perceptions and attitudes towards issues surrounding marine litter. September, 08. MARLISCO Project Deliverable. Security: Public, www.marlisco.eu.

Hartley, B., Pahl, S., & Thompson, R. C. (2014, in preparation). Perceptions on Marine Litter in Europe. Manuscript in preparation. Plymouth University.

Kershaw, P., Alcaro, L., Garnacho, E., Doyle, T., Maes, T., & Paiting, S. (2013a). MARLISCO D1.3 Review of existing policies that may be applied to mitigate the impact of marine litter. 2013, July, 26. MARLISCO Project Deliverable. Security: Public, www.marlisco.eu.

Kershaw, P., Hartley, B., Garnacho, E., & Thompson, R. (2013b). MARLISCO D1.1. Review of the current state of understanding of the distribution, quantities and types of marine litter. July, 28. MARLISCO Project Deliverable. Security: Public, www.marlisco.eu.

Maes, T., & Garnacho, E. (2013). MARLISCO D1.2 Summary of current methods of monitoring and assessment for marine litter. 2013, July, 24. MARLISCO Project Deliverable. Security: Public, www.marlisco.eu.

MARLISCO Project. www.marlisco.eu (23.07.2014).

MARGOV. http://margov.isegi.unl.pt (23.07.2014).
Mossbauer, M. (2013). MARLISCO D3.1 Marine Litter web portal, including educational pack publically available. July, 29. MARLISCO Project Deliverable. Security: Confidential.
Orthodoxou, D. L., Loizidou, X. I., & Loizides, M. I. (2013a). MARLISCO D2.3 Analysis of the processes and solutions of the 72 best practice examples. November, 13. MARLISCO Project Deliverable. Security: Public, www.marlisco.eu.
Orthodoxou, D. L., Mossbauer, M., & Loizidou, X. I. (2013b). MARLISCO D2.2 Web-database of 50 short and 10 detailed best practices. December, 18. Security: Public, www.marlisco.eu.
Santonocito, A. (2012). MARLISCO D7.1 Project Management Plan. October, 30. MARLISCO Project Deliverable. Security: Restricted.
Vasconcelos, L., & Caser, U. (2012). MARGOV – building social sustainability. *Journal of Coastal Conservation, 16*, 523–530.
Veiga, J. M. (2013). MARLISCO D5.1 Rules of European Video Contest, in English. March, 31. MARLISCO Project Deliverable. Security: Public, www.marlisco.eu.
Veiga, J. M., Vlachogianni, T., Pahl, S., Thompson, R. Kopke, K., Doyle, T., Hartley, B., Maes, T., Orthodoxou, D., & Loizidou, X. (2014, submitted). Enhancing public awareness and promoting co-responsibility for marine Litter in Europe: the challenge of MARLISCO. Marine Pollution Bulletin – special issue.

6.3 Researching Classroom Assessment of Inquiry Competences. The ASSIST-ME Project

Jens Dolin – University of Copenhagen, Denmark

Background

Our modern society and increased insights into learning and teaching make an increased demand on students' outcomes within science education – the educational goals are constantly becoming more and more ambitious, including both professional and generic abilities. These wider goals are expressed in competence terms, indicating, for example, inquiry or modelling processes, as well as innovative or argumentative processes, which students are expected to be able to perform. Much has been gained about how to teach to guide students to attain these competences, for instance through FP7 projects: many FP7 projects have established extensive programmes for teacher professional development related to the teaching geared to these wider competences.

But a fundamental problem is that the predominant assessment and evaluation strategies are not able to adequately capture these wider goals. Most teacher assessments are still using relatively traditional test formats, based on a post-positivist paradigm and mostly as summative assessment without utilizing the learning potential of formative assessment. We are well aware that the assessment approach has a deciding influence on the teaching and "teaching to the test" is a well-known, and understandable, teacher reaction to the test regimes all too often invading educational systems. Thus, we can expect traditional assessment strategies encourage 'traditional' teaching and with this, most existing assessment and evaluation systems are blocking teaching enabling students to acquire new learning goals. It is with this in mind that it is necessary to develop new assessment strategies which able teachers to capture student learning towards these wider goals and to influence educational policymakers to implement these in national educational systems.

The aims of ASSIST-ME

The overall aim of ASSIST-ME (*Assess Inquiry in Science, Technology and Mathematics Education)* is to provide a research base on effective uptake of formative and summative assessment for inquiry-based, competence oriented, Science, Technology and Mathematics (STM) education within primary and secondary education applied in different educational contexts in Europe. In addition, a further aim is use this research base to give policy makers, and other stakeholders, meaningful guidelines for ensuring assessment strategies enhance learning in the wider remit of STM education.

As ASSIST-ME is a research project, the work within the project is driven by formulated research questions. These are:

- What are the main challenges related to the uptake of formative assessment in the daily teaching-learning practices in science, technology and mathematics within primary and secondary schools in different European educational systems? Sub-research questions related to this area: In their efforts to enact innovative inquiry-based teaching-learning sequences, how do teachers approach the need to monitor student learning as it develops? To what extent do they use structured formative assessment and in what formats? What systemic support measures and what tools do teachers need in order to integrate formative assessment of student learning in their classroom practices?
- What changes are needed in summative assessment practices? Sub-research questions related to this area: What changes are needed to bring summative assessment practices to be consistent with the learning goals of IBE within STM? What changes are needed to bring summative assessment practices to ensure that they support rather than inhibit formative assessment practices?
- How can formative and summative assessment methods, including the use of ICT, be used interactively to promote learning in inquiry-based STM?
  How can research-based strategies for the use of formative/summative assessment be adapted to various European educational traditions to ensure their effective use and avoid undesirable consequences?
  Sub-research questions related to this area: How can the diverse roles of summative and formative assessment be clearly delineated for teachers and what strategies can help make appropriate use of both, each to fit its own desired purposes?
  How can relevant stakeholders be invited to take co-ownership of the research results and how can a partnership between researchers, policy makers, and teachers be established in order to secure relevant actions following meaningful and effective implementation guidelines?

To realize the project aims and to be able to answer the research questions, some important elements within ASSIST-ME are:

- A common understanding of key concepts and processes (for reliability reasons) and a mapping of country (specific) educational variables (such as teachers' working conditions, common assessment practices, educational policy-making processes etc.).
- Deciding competences (domain specific and generic) on which to focus as representing IBSTME and defining a learning progression with operational criteria of the competence (and give a canonical case in each subject and level).
- Develop assessment methods capable of assessing the chosen competences.
- Determine research methods able to monitor and evaluate implementation processes.
- Involve teachers in teaching for the competences and adapting the assessment methods in their class rooms.
- Carry through research (together with the teachers) on the implementation processes (what supports/undermines the uptake of formative teaching/assessment strategies?).
- Summarizing the results through effective guidelines and recommendations.
- Continuously engage stakeholders in the process

The overall goal is to change practice and also, where applicable, policy!

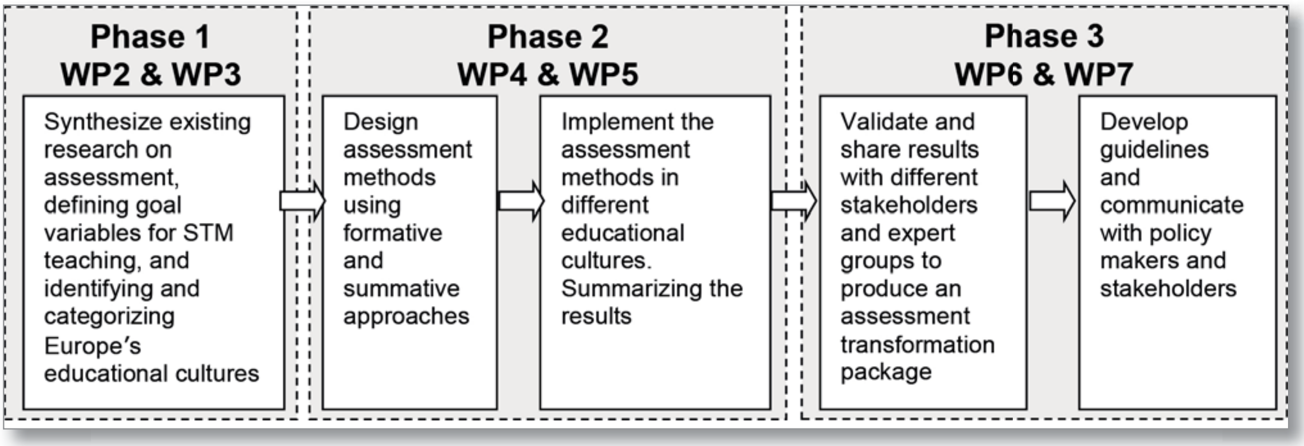


Figure 1. Project structure

The project at a glance

The project is running from January 2013 till December 2016. It is structured in three phases (see Figure 1).

The implementation processes using the developed assessment methods in classrooms will start in September 2014.

The project has ten partners from eight countries:

1. University of Copenhagen, Department of Science Education (Coordinator)
2. University of Kiel, Leibniz Institute for Science and Mathematics Education
3. University of Cyprus, Department of Educational Sciences, Learning in Science Group
4. Fachhochschule Nordwestschweiz, Pädagogische Hochschule, Centre for Science and Technology Education
5. Centre National de la Recherche Scientifique, Lyon, ICAR, ENS Lyon
6. King's College London, Department of Education & Professional Studies
7. University of Jyväskylä, Department of Teacher Education
8. University Joseph Fourier Grenoble 1, Teacher Education Institute, Educational Science Laboratory
9. University of South Bohemia
10. Pearson Education International

In order to change practice and influence policy, the research and implementation is performed in close collaboration between researchers, teachers and policy makers.

The model in Figure 1 indicates the importance of establishing close relationships between the key actors in education for change to happen.

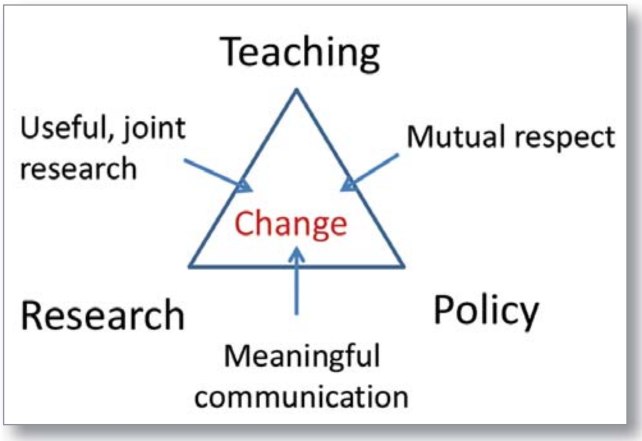


Figure 2. Change Model

The collaboration is managed through *National Stakeholder Panels* with representatives from industry, ministry, heads' association, teachers' association, teacher education institutions, media, Parliament, and foundations. The representatives are selected through a network analysis method developed within the project. These panels discuss findings, give feedback to the whole process and also put forward suggestions for research questions to be followed by local researchers and teachers.

A further, important collaboration organ is the *Teacher Expert Panels/Local Working Groups,* with teachers teamed up with researchers. In each country, two groups each with ten teachers, each collaborate with two researchers. The teachers teach different STM subjects, at different educational levels, ensuring that the project, at a European level, covers all STM subjects at primary, lower secondary and upper secondary levels. These groups are responsible for implementing the assessment methods in the classrooms and for performing the research, i.e. extracting the empirical data that is to be the basis for the findings and recommendations.

Overview of findings from phase 1

WP2 was responsible for synthesizing existing research on assessment of inquiry-related competences. Based on these reviews (made public on the project web site), the following were determined: a common definition of inquiry, an overview of the key competences within science, technology and mathematics, a common understanding of formative and summative assessment and a definition of these elements, broad enough to cover the general understanding within the research community and narrow enough to be a basis for reliable research.

Some examples:

> *"Within the ASSIST-ME project, inquiry-based education (IBE) is understood as an approach to teaching and learning that supports students' learning in science, technology and mathematics. IBE has a procedural character with process steps that are characterized by student activities and underlying competences. It is in the nature of inquiry that the process is not completely linear and that the activities – and thus the underlying competences – overlap. Inquiry-based approaches come under different names within the three domains science, mathematics and technology: scientific inquiry in science, problem solving in mathematics and engineering design in technology, respectively."*

This general definition is then followed by specific definitions of inquiry-based education in science, technology and mathematics.

> *"Formative assessment is 'assessment for learning,' which aims at supporting and improving student learning as it takes place. It is classroom-based, individual as well as criterion referenced and has a procedural character: students conduct activities, data is collected and interpreted related to achievement goals, a judgement is made related to student-based criteria and decisions on how to reach next learning steps are made which then leads to new student activities. At all stages there is feedback from teacher to student and from student to teacher (and from student to student) related to the teaching-learning process. Formative assessment thus has the function of individual support but at the same time, gives students an active role in all steps of the assessment process.*
>
> *Within the ASSIST-ME project, the following three criteria are chosen to characterize formative assessment:*
>
> 1. *Active student involvement in the whole assessment process.*
> 2. *The criteria used in the judgment of the process and outcome of a student activity are student-referenced, as well as subject-specific (meaning that the feedback to the student is adapted to the individual student).*
> 3. *The assessment ends with further activities which promote (further) learning."*

WP3 involves a mapping of the variables for STM teaching, and identifying and categorizing Europe's educational cultures according to these variables. The purpose is to adapt the findings from the implementation process to the national contexts and to synthesize the finding to formulate recommendations at a European level.

Outline of future research in the project

WP4 has been responsible for developing the assessment methods able to capture the selected competences.

The project has decided to concentrate on one core competence within each of the MST domains and three cross-disciplinary competences. The domain specific competences are:

- Empirical investigations in *science* (Planning, performing, analysis and evaluation of data, presentation and representation of findings)
- Problem solving in *mathematics* (Collection of information, problematization, presentation and representation of findings)
- Design in *engineering/technology*

The three cross-disciplinary competences are:

- Argumentation
- Modelling
- Innovation

Each competence has been defined and a learning progression has been proposed for each competence together with examples of how to teach to enable students to acquire the competence.

The selected assessment methods are

- Questioning and other interactions 'on the fly'
- Marking (Grading and Feedback)
- Student Peer- and Self-Assessment
- Structured Classroom Dialogue

Each method is described and different assessment tools (diagnostic tests, portfolios, student-constructed interviews, rubrics, etc.) are included.

WP5 has developed a research plan which each Local Working Group follows.

This plan contains instruments and other means of data collection to secure the reliability of the research. As a supplement to the common research questions and methods, each Teacher Expert Panel/Local Working Group formulates research questions relevant for the national context, but within the common framework.

Project web site

All deliverables and other material are accessible at the project web site:
www.assistme.ku.dk

6.4 TEMI – Teaching Enquiry with Mysteries Incorporated

Johanna Dittmar, Dörte Osersehlt & Ingo Eilks – Universität Bremen, Germany
Dvora Katchevich, Malka Yayon, David Fortus, Ran Peleg, Avi Hofstein & Rachel Mamlok-Naaman – Weizmann Institute of Science, Israel

Abstract

TEMI is a project funded by the European Commission within the 7th Framework Programme (FP7). The project involves a cooperation of 13 partners from 11 European countries. TEMI focuses continuous professional development of science teachers for the high school level. The training concept is focused on innovative elements to promote inquiry-based science education. In this paper, a classroom example on the "Magic Sand" is used to illustrate the TEMI philosophy.

Introduction

In recent years, many research studies and educational policy papers described that there is still a lack in the popularity of science subjects and the corresponding level of motivation among high school students. To help close this gap, the project *TEMI – Teaching Enquiry with Mysteries Incorporated* was launched (www.teachingmysteries.eu). TEMI is funded under the 7th Framework Programme of the European Union in the category "Capacities, Science in Society, Coordination Action". It includes 13 partners from 11 European countries and focuses the continuous professional development of high school science teachers in the field of inquiry-based science education.

The TEMI philosophy

TEMI is based on four theoretical elements to exploit the full potential of inquiry learning in science education (Sherborne, 2014):

1. Create curiosity with mysteries

TEMI uses unexpected and unfamiliar phenomena – the mysteries – to raise curiosity and challenge students' self-directed learning activities. In TEMI, a mystery is understood as a phenomenon or event that provokes the perception of suspense and wonder in the learner to initiate an emotionally-laden "want to know" feeling, which leads to raising curiosity and which initiates the posing of questions to be answered by inquiry and problem-solving activities. In TEMI-mysteries, cognitive aspects are just as important as the affective side. The challenging character of the mysteries is suggested to raise motivation and increase the enthusiasm for science education.

2. Teaching science with the 5E learning cycle

The TEMI activities are structured along five steps, so that learners can themselves gradually develop into self-confident researchers (Bybee et al., 2006). The individual phases encompass (Figure 1):

- Engage: Presentation of a mystery to create motivation/attention in the learners and for developing hypotheses
- Explore: Planning and executing an inquiry for collecting observations and evidences
- Explain: Finding and formulating a sound explanation based on scientific concepts
- Extend: Practicing and applying the newly learned concepts
- Evaluate: Assessing the learning process

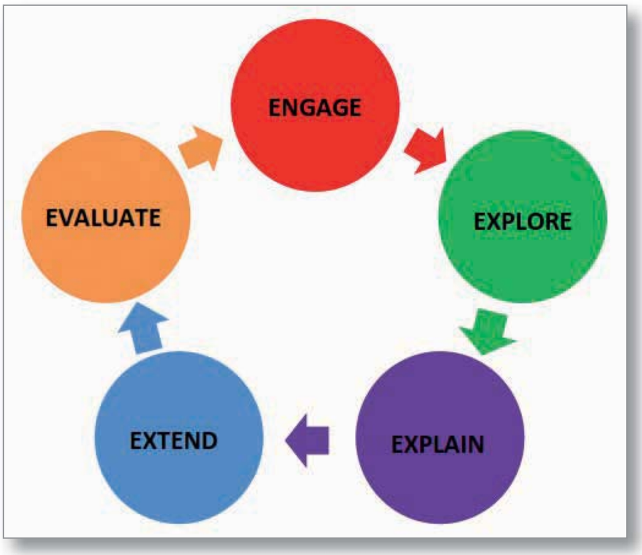


Figure 1. The 5E model for inquiry learning

3. Teaching with gradual release of responsibility

TEMI describes different levels in which the teacher can act as expert, guide or coach. Teachers learn how to organize the learning process corresponding to the skills of the learner in inquiry-based problem-solving. The teachers learn how detach from their role as experts and take on the role of a supervisor, who becomes active only on request by the student. TEMI teaching materials are developed to allow for different degrees of openness to be used in the range from structured via guided to open inquiry.

4. Maintain motivation with showmanship

TEMI involves professionals in communication (actors, magicians, rhetoric experts, etc.) to develop skills with the teachers in the appealing and provoking presentation of the mysteries. It is suggested that the effective demonstration of the mystery may well contribute to and maintain student's motivation. In theatres or magic shows, there are various presentation techniques that can also be used in the classroom.

An example on "The Magic Sand"

Aside from providing teacher continuous professional development, TEMI is also engaged in developing classroom activities and teaching materials. One example recently developed by the

Weizmann TEMI team piloting by the TEMI partner countries, Israel (Katchevich, Yayon, Peleg, Mamlok-Naaman, 2014) and Germany, is about "The Magic Sand" (http://sealsand.com, www.futuresand.de). Magic sand is sand whose surface has been treated with a coating. The surface changes from a hydrophilic to a hydrophobic (water-repellent) character. This leads to an unexpected behaviour of the sand when it comes into contact with water. The sand does not get wet, neither in contact nor under water. It clumps under water and once the sand is taken out of the water it instantly dries. For this reason, the sand is not only used in oil spillage, flood protection and industry, but also allows underwater worlds to form (Figure 2).

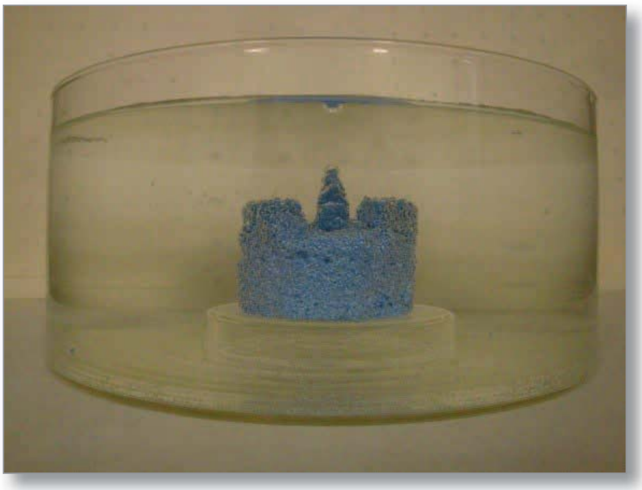


Figure 2. A "magic sand underwater castle"

Phenomena, like the behaviour of the magic sand, are typical for TEMI activities. The behaviour of the sand is uncommon and mysterious. While it totally contradicts the expected behaviour of sand, it challenges the learner. The commonality of regular sand allows for creating a small story to introduce the example, the hazard-free nature of the sand enables opportunities for presenting the mystery in different ways and gives students the chance to inquire autonomous into the phenomenon.

A presentation of the mysterious behaviour of the magic sand is the first step to "Engage" the learner with the mystery and to raise curiosity and motivation. The teacher can perform a motivational presentation, in which a sand castle under water is built in front of the learner (ORF Kinderprogramm, 2014). Students make observations, as well as try the mystery out by their own. However, they receive at first only regular sand. During their initial try, the students recognize that the phenomenon does not appear with regular sand. This result provokes questions related to the differences between the two sorts of sand.

Now, each group of students is given samples of magic and regular sand. They examine the surfaces and the sands' behaviour (Figure 3). The phase "Explore" starts with students first inquiring playfully into the behaviour of the sands. The learners get support materials that can be used with respect to their skills. The materials introduce ideas, e.g. to have a closer look at the sand's surface, or to undertake experiments about the behaviour of the sands in different hydrophilic and hydrophobic liquids.

This leads to "Explain" the mystery. The learners identify the concept of hydrophilic and hydrophobic behaviour as the reason for the behaviour of the sands. The students learn that the magic sand is coated with a hydrophobic surface leading to the impossibility of the sand getting wet.

Subsequently, there is a widening, or deepening of the learning. As a simple example to "Extend" the mystery, a report on issues of environmental protection is introduced, via an Internet search. The issues are about technical processes where the hydrophobic sand is used.

Figure 3. Inquiring into the magic sand

Figure 4. Impressions from a teacher professional development workshop in Israel about enquiry learning on the example of the magic sand

Finally, the teachers "Evaluate" whether the learners built up an understanding of the scientific concept behind the magic sand. Here the students might be asked to explain further applications of the magic sand or whether they could apply the concept of hydrophilic and hydrophobic behaviour in a different context.

Conclusions

TEMI intensive teacher workshops are to be organized by the partners from Milan (Italy), Bremen (Germany), Limerick (Ireland), Sheffield (UK), Leiden (The Netherlands), Prague (Czech Republic), Rehovot (Israel), Vienna (Austria) and Borre Vestfold (Norway) in their respective countries. Figure 4 gives some impressions from a respective workshop on the magic sand in Israel. Each teacher continuous professional development course lasts for two full days of contact time with phases of individual activities in-between. Teaching materials are to be developed in all the corresponding local languages and exchanged via translation. Additional features, like print and web-based resources, as well as a smartphone app, are to be included to help make TEMI visible beyond the teacher education seminars. Processes of internal and external evaluation are to be set up to examine the effects of TEMI.

References

Bybee, R., Taylor, J. A., Gardner, A., Van Scotter, P., Carlson, J., Westbrook, A., & Landes, N. (2006). *The BSCS 5E Instructional Model: Origins and Effectiveness.* Colorado Springs, CO: BSCS. Retrieved from: http://bscs.org/sites/default/files/_legacy/BSCS_5E_Instructional_Model-Full_Report.pdf (25.05.2014).

ORF Kinderprogramm (2014). *Eierspeisen in der Schale und Sandburg im Wasser*. Retrieved from: okidoki.orf.at/dateien/25102_Experimente_Genau08_Eierspeise_in_der_Schale_und_Sandburg_im_Wasser.pdf (25.05.2014).

Sherborne, T. (2014). *Enquiry & TEMI CPD*. Retrieved from: www.teachingmysteries.eu/wp-content/uploads/2013/12/Enquiry-CPD.pdf (25.05.2014).

Katchevich, D., Yayon, M., Peleg, R., & Mamlok-Naaman, R. (2014). *The sea-sand overseas.* Retrieved from: http://stwww.weizmann.ac.il/g-chem/temi/chomarim4.html (25.05.2014).

6.5 Promoting Stakeholder Engagement in Research Programming in Food and Health

Klaus Hadwiger – Life Science Center, Universität Hohenheim, Germany
Daniela Coutinho – SPI-Sociedade Portuguesa de Inovação, Portugal

Abstract

Over the past decade, most EU Member States have identified food and health as key priorities. This occurs in response to the increases in obesity and diet-related chronic diseases, such as diabetes and cardiovascular diseases, amongst their populations.

Attempts to increase public awareness on appropriate ways to eat more healthily do not seem to have led to significant changes in patterns of food purchase and consumption. It has thus become obvious that the development of effective measures for improvement requires further systematic research and innovative approaches.

In this context, the project INPROFOOD – towards inclusive research programming for sustainable food innovations (www.inprofood.eu), funded by the European Community's Seventh Framework Programme for research, technological development and demonstration (grant agreement no. 289045) – provides one approach for overcoming this necessity by bringing together scientific and civil society community in order to debate food and health related problems. The project considers that governance of research and technological developments facilitate sustainable and inclusive solutions. In particular, it aims at helping to further incorporate public concerns and providing feedback to underpin the policy debate on a "new social contract" between science and society to support practical guidelines for inclusive, sustainable research designs.

Interviews with stakeholders and European Awareness Scenario Workshops have shown that stakeholders, especially CSOs, feel valued to be involved in defining the future of research. Common topics have also been identified for future research. A "European Open Space Conference" has addressed how we can shape the future of food and health research for 2020, covering areas such as education, citizen involvement, eating patterns and industry-science partnerships. In addition, around 1 700 young people have contributed to Play-Decide games on a Healthy Lifestyle in different European countries. These activities have facilitated participatory method take-up, contributing to adapt food and health research governance in order to implement sustainable and inclusive solutions. Furthermore they have helped to increase the incorporation of science in society issues into research systems as well as improving transnational research programming cooperation.

Eighteen partners from thirteen European countries have joined forces in INPROFOOD to address these ambitious tasks during three years of intensive activities. The aim of the multidisciplinary partnership has been to foster dialogue and mutual learning between industry, academia and civil society in the earliest stages of the research processes. The project is led by the University of Hohenheim, Germany.

Project description

The project INPROFOOD towards inclusive research programming for sustainable food innovations project (www.inprofood.eu), funded by the European Community's Seventh Framework Programme for research, technological development and demonstration (grant agreement no. 289045), aims at bringing together civil society, academia and business to tackle policy questions on food and health research. It considers that governance of research and technological developments facilitates sustainable and inclusive solutions. In particular, it aims at helping to further incorporate public concerns and providing feedback to underpin the policy debate on integrating the society into science to support practical guidelines for inclusive, sustainable research designs.

The project was launched on the 1st of November, 2011, for a duration of 36 months, with 18 partners coming from 13 countries (Austria, Belgium, Denmark, France, Germany, Greece, Italy, the Netherlands, Portugal, Slovakia, Spain, Turkey, UK). The consortium is coordinated by the University of Hohenheim and includes research institutions, universities, technological centers, innovation management entities and international organizations with extensive know-how on food and health.

Context of INPROFOOD

There is a well-recognised connection between diet and non-communicable diseases (NCDs) such as cardiovascular disease, cancer, chronic lung diseases and diabetes, and their associated conditions of heart attacks, stroke, bronchitis and obesity. In fact, the World Health Organization (WHO) reported that in 2008, NCDs were responsible for 63% of global deaths. The WHO has also identified a number of potential counter actions for NCD prevention related to diet, including incentive fiscal measures and food product reformulation, both of which require further research and innovation.

In the context of an increasing global population, it was also recognised that food production needed to increasingly consider social-economic and environmental sustainability in order to meet society's needs. In line with this recognition, a recent Science and Technology Options Assessment workshop, held in December 2013, focused on Europe's role in feeding the world in 2050. It considered ways in which innovation in plant breeding, agriculture, food processing, and waste reduction, as well as crop and food residue recycling, could contribute to increased sustainability in this area.

It is clear that innovation and research need to play an important role in addressing these challenges. To ensure that efforts are directed to the benefit of citizens, addressing the ambitious task of tackling poor diet and food security requires dialogue and mutual learning between industry, academia and civil society already at the programming stage of research processes.

How is INPROFOOD being implemented?

The project activities are conducted following seven work packages, each of them aiming to achieve specific objectives, indicated as follows: WP1 aims to investigate current processes and structures of research programming; WP2 and WP3 aim to develop stakeholder engagement at national and European levels – European Awareness Scenario Workshops (EASW), Play-Decide-Games, European Open Space Conference; WP4 aims to stimulate uptake of concrete initiatives of societal engagement in food and health research; WP5 aims to contribute to improved methodology used in Science in Society research projects and to conduct the evaluation of employed methods; and WP6 aims to facilitate communication with the project's target audience.

A starting point in INPROFOOD's endeavour was to analyse the current processes, structures and actors involved in research funding related to food and health.

At a first stage, *desk research* (WP1) was conducted by INPROFOOD partners at the country level (Austria, Germany, Greece, Italy, Netherlands, Portugal, Scotland, Slovakia, Spain, UK), and at the EU level aiming to identify these aspects as well as pinpoint relevant documents for this subject including strategic plan development and prioritization of topics. *Interviews* with actors involved on a particular topic with a food and health research component funded by public research programmes followed the desk research.

Following the mapping of the current state of play, the project sought to investigate the desired scenarios envisaged by the stakeholders. Consequently, *35 European Awareness Scenario Workshops* (*EASWs*, WP2) on research programming for a sustainable production of healthy food, were held in three series and in 13 different countries, bringing together a broad range of stakeholders to develop shared visions of socially acceptable, trustworthy, and transparent conditions for developing health-related innovations in the food area.

Play Decide Games with young people (14–21 years olds) were implemented in seventeen science centres in 11 countries evenly spread throughout Europe (WP2). These serious games were simple and effective ways to learn to discuss with confidence about the issues raised by contemporary science and technology. The main goal of these games was to propose solutions, define strategies and policies for action, and to inform the decision and policy makers of the ideas and plans developed during the game. Within INPROFOOD, four policy positions were created for consideration by participants. These concerned the degree of government regulation and the level of personal responsibility vs governmental responsibility on the global issues of obesity and healthy lifestyles.

Additionally, the consortium organized a *European level conference* (WP3) in Brussels, aiming for mutual learning at the European level, involving 70 participants from 18 different countries. The conference ran under the heading "Food and Health – Research 2020" using a method first developed in the USA in the 1980s called the Open-Space-Technology-Method. This method starts from the premise that mutual learning was best undertaken with some form of structure, but with as much freedom as possible and followed an open call, first come first served method of recruitment. A total of 18 workshops – in three different time slots of 1 to 1,5 hours – were conducted, with very diverse and exciting results. At the end of the day, the group gathered again for reflection, shared visions and feedback.

A recent activity of INPROFOOD included the organization of a *workshop* (WP4), by the European delegation of the World Health Organization (one of the major partners of the project) that gathered around 70 participants to discuss increasing public engagement in research through a whole-of-society approach. The event consisted of plenary and break-out sessions, to allow in-depth discussions about the possibilities of broad stakeholder participation in research programming in food, nutrition and health, while keeping principles of transparency and mutual respect. This activity of the project is meant to assess the "effectiveness" of the stakeholder engagement activities in the project, based on "information translation", using a participant and organizers questionnaire following a systematic process, interviews with key participants and an audit trail of the process used.

Some of the main reflections from desk research and interviews with stakeholders
In most countries examined, the national government sets thematic priorities for research.
Dedicated strategies and programmes on food and health do not yet exist in most countries analysed. Much of the research uses the responsive (bottom-up) mode. Except for the UK, countries examined do not have an overarching strategy for food and health research, but often have broad strategies/ programmes that include a significant food and health component.
Stakeholder engagement is not required for research programming in the public sector across all countries examined. Stakeholder engagement to the extent of industry, government and research institutions is not uncommon; but the involvement of civil society actors or the public in general is a less common practice.
Evaluation of proposals seems to be over dominated by previous experience, demonstrated through a publication record.

Table 1. Main reflections from desk research and interviews with stakeholders on the current scenarios

Some of the main reflections from the European Awareness Scenario Workshops (EASWs)
Decisions on topics to be funded in food and health should derive from societal demand and should involve stakeholders in a bottom-up process; representatives of all stakeholder categories, but mostly of the public and private sector, should be included.
Decision making on project funding should involve stakeholders other than researchers, scientists and funders (e.g. CSO), and should not be influenced by a dominating stakeholder and be independent and impartial, without conflicts of interest.
Stakeholders believe that projects funded should ensure the applicability of research results and that funding criteria should be clear and credible (and should include e.g. an ethically responsible attitude towards research, an orientation towards public interest, among others).
Research results should be accessible to all stakeholders (preferably by open access); Public interest and social benefit should be more important than economic interests.
Evaluations should be conducted objectively, impartially, without conflicts of interest and by independent, competent evaluators.

Table 2. Main reflections from the European Awareness Scenario Workshops (EASWs) on the desired scenarios

Results

Current and desired processes and structures in research programming in food and health

Some project reflections following the desk research and the interviews (WP1) with actors include those presented in Table 1.

Following the mapping of the current state of play, the consortium sought to investigate the desired scenarios in Research Programming in Food and Health, as envisaged by the stakeholders, through *European Awareness Scenario Workshops* (*EASWs*). Some of the project reflections include those summarized in Table 2.

Serious games for youth engagement

Play-Decide Games have proven to be a valuable activity to engage youth in serious problems in food and health. The majority of young people involved believe that decisions and choices related to lifestyles should be left to the citizens and it was their own responsibility to be healthy. They also thought that governments played a major role and should help citizens by regulating certain areas such as labelling, food prices and supporting healthy food providers, providing infrastructures and encouraging physical activities. Other topics raised during the games were the following: fast food, eating disorders, education/lack of information, school canteens, healthy eating, social aspect of food/influences, body image, behaviour change, sports, or labels.

European open space conference for stakeholder engagement

In the *European Open Space Conference,* the majority of participants took part in workshops concerning the involvement of different players in research on nutrition and food, as well as in workshops discussing the general question of how healthy food and healthy eating could be defined. The third highest participation rate was with workshops that covered the topics of education and communication. Issues of sustainability and regulations in food productions and supply, food safety and food supply security, as well as the question on whom to involve in research projects, were also seen as relevant in different workshops. A podcast was developed on this event and was available on the project webpage. This podcast explained what the Open Space methodology was all about, set out how the method contributed to the aims of the INPROFOOD project, and finished with impressions of a number of participants, who shared their views on the methodology, and what they found important topics for future research on food and health.

Outlook & reflection

The activities undertaken in INPROFOOD are facilitating participatory method take-up, contributing to adapt food and health research governance in order to implement sustainable and inclusive solutions and underpinning the policy debate on a "new social contract" between science and society. Furthermore they are helping to increase the incorporation of science in society issues into research systems, as well as improving transnational research programming cooperation.

References

World Health Organisation (2011). Global Status report on non-communicable diseases. Retrieved from: http://www.who.int/nmh/publications/ncd_report_full_en.pdf (23.06.2014).

European Parliament, Science and Technology Options Assessment (STOA), Workshop: How to feed the world in 2050?, December 2013, Retrieved from: www.europarl.europa.eu/stoa/cms/home/events/workshops/feeding (23.06.2014).

INPROFOOD partners also include: Dialogik (DE), SPI (PT), Universiteit Maastricht (NL), University of Surrey (UK), Eugene Rowe (UK), Observa (IT), WHO (CH), FORTH (EL), European Food Information Council (BE), Buckenhuskes Herbert Johannes (DE), European Network of Science Centres and Museums (BE), Science Shop Vienna - Wissenschaftsladen Wien (AT), Hacettepe Universitesi (TR), Centro tecnológico agroalimentario (ES), Univerzita Komenskeho V Bratislave (SK), Agropolis (FR) and University of Copenhagen (DK).

6.6 INQUIRE: Inquiry-based Teacher Training for a Sustainable Future

Suzanne Kapelari – Universität Wien, Austria
Elaine Regan – King's College London, UK
Justin Dillon – King's College London, UK
Gail Bromley – Plant Values, London, UK
Asimina Vergou – Botanic Garden Conservation International, London, UK
Julia Willison – Royal Botanic Gardens Kew, Richmond, Surrey, UK
Costantino Bonomi – MUSE, Trento, Italy

Abstract

The EU FP7 INQUIRE Project was developed and implemented to support science literacy in Europe through teacher training courses, focussing on the integration of Inquiry-Based Science Education (IBSE) into informal and formal education programmes. Courses were developed and offered in 14 sites across 11 European countries with a cohort of 576 participants that included both teachers in the formal education system and also education officers in informal education sites (Botanic Gardens, Natural History Museums etc). Botanic gardens and similar 'Learning Outside the Classroom' (LOtC) sites are inspirational sites that can provide training for teachers and educators on critical issues such as conservation of our natural resources, sustainability and threats to our future, such as climate change. Integrating these themes into activities using IBSE pedagogy provides an exciting and stimulating programme which encourages teachers and informal educators to develop their proficiency in IBSE and to become reflective practitioners as well as raising awareness of these issues. To evaluate INQUIRE project outcomes, a qualitative evaluation strategy was carried out by King's College London that drew on frameworks, such as Miles and Huberman, Guskey and Hatton and Smith. The findings and conclusions fell into key areas of interest in the project: the collaborative development of science teaching in Europe; the status of learning outside of the classroom; the influence on the formal and informal sector; and the ability of botanic gardens to support LOtC.

Project description

Current science education reform initiatives require fundamental changes in how science is taught and in how teachers are supported to engage in alternative ways of science teaching. One current approach is the incorporation of inquiry-based science education (IBSE) into the everyday school science curriculum. To help make this change happen, teachers need opportunities to participate in a variety of professional development experiences that foster an understanding of science and inquiry-based science teaching (Rocard, 2007).

Research has also shown that learning that includes activities based outside the classroom is highly motivating, not only for children but also for teachers (Dillon et al., 2006). The UK Government's education manifesto `Learning outside the Classroom´ was launched to emphasis this key issue and Europe has already recognized the potential of Learning Outside the Classroom (LOtC) venues to support the implementation of IBSE methods on a large scale (Rocard, 2007). The content of the INQUIRE training courses focused on various aspects of biodiversity loss and climate change, drawing on the expertise and inspirational settings for the courses in Botanic Gardens and natural history centres across Europe. With more people living in cities, botanic gardens, which provide excellent opportunities for education in major cities worldwide, offer some of the only outdoor learning sites for children to gain first-hand experiences of IBSE.

The EU 7th Framework Science and Society Project, INQUIRE: Inquiry-Based Teacher Training for a sustainable future was a three year project running from December 2010 until November 2013. It joined 17 partners and was set up to foster the development and implementation of IBSE in both formal and informal education systems by developing, testing and implementing IBSE training courses in 11 European countries. One of the key aspects of this project was the provision of a 'long-term' training course (60 hours +) over a prolonged period and a course where there was a real emphasis on reflective practice being developed by both course participants and Consortium Partners. This was a change from short, sharp training sessions that often were the objectives of projects and which, although they could result in high numbers of participants, unfortunately did not actually effect real behavioural and attitudinal change in those participating.

To ensure high quality project delivery a 'Quality Management Plan' was developed and agreed in the initial period of the project. The plan outlined how evidence for project outcomes would be collected through surveys, on-line questionnaires, case studies submitted by partners during partner meetings, interviews, observation and Portfolios of Evidence (PofE). This plan was implemented and augmented as necessary over the project period. Regular support was provided by both the Quality Management Team and the full INQUIRE Management Board including provision of partner visits, support telephone calls, on-line via Glasscubes and through the INQUIRE website and regular newsletters.

Two sets of INQUIRE courses were run over the project period. The courses were piloted by partners early on in the project (September 2011 and July 2012) and for post evaluation of the pilot course, a second course was run (autumn of 2012 and the summer of 2013). The project partners used reflective practice and evaluation processes to analyse good practice, effectiveness and impact of the courses both with their course participants, through the consortium partnership meetings and through support sessions provided by the Quality Management team and the Management Board. The courses were refined and improved through this process, resulting in enhanced courses with more polished delivery and good impact. Overall, the courses reached a total of 576 participants; 250 in the pilot courses and 326 in the second set of courses. Course participants included educators in LOtC sites, primary, secondary and student teachers, education authority officers and other staff from LOtC sites. Throughout the INQUIRE training courses, teachers and botanic garden educators had also been encouraged to learn with, and from, each other and to develop a shared understanding of how IBSE could be facilitated in class and in botanic gardens and natural history museums. Sustainability was key to the project and this was attained through the community of practice that emerged amongst partners and through the running of 'Train the Trainer' courses to cascade knowledge and experiences gained through the project to other LOtC institutions.

Methodology

To evaluate project outcomes, King's College London applied a qualitative evaluation strategy that drew on evaluation frameworks such as those of Miles and Huberman (1995), Guskey (2000), Hatton and Smith (1995). The study centres examined the INQUIRE partner's design, implementation and delivery of their IBSE teacher training courses using experience in the field of science education and existing research literature.

Findings emerged from the analysis of 15 INQUIRE teacher and educator training courses. These courses were developed and implemented in a variety of contexts (national, local and political). Consequently, the research data consisted of a participant observer perspective on a range of data sources. The data included semi-structured interviews, portfolios of evidence (PofE), and artefacts such as proposed and amended course design posters, course plans, lesson plans, outdoor IBSE activities, field notes from support visits and partner meetings and contributions to project deliverables. Partner PofE, in turn, drew on the findings and reflections from participants on individual courses as well as partner course tutor's/organiser's reflective practice.

Results

Findings are summarised in four areas of success emerging from the design, implementation and evaluation of the IBSE teacher-training courses:

1. Contribution of the INQUIRE project to the development of science teaching
2. The status of learning outside of the classroom
3. Influences on the formal and informal sectors
4. Botanic gardens and natural history museums' ability to support LOtC

Due to the limited length of this paper, results are presented for the first area only. For further outcomes please refer to the INQUIRE website and download the full INQUIRE management report (http://www.inquirebotany.org/en/resources.html).

Contribution of INQUIRE project to the development of science teaching

The INQUIRE course has contributed to the development of science teaching, evidenced in the range and quality of the course material prepared, resulting in predominantly positive feedback from course participants with strong indications of changing practice noted across Europe. This has largely been a result of the use of practical activities within the gardens that allowed teachers and educators to trial IBSE in LOtC settings and in their own classrooms. These strategies on the course were most successful in increasing IBSE knowledge and skills because they could be used immediately or act as sources of inspiration for adaptation.

Several INQUIRE courses were structured around demonstrating IBSE activities and lesson plans, in fact encouraging, participants to try the activities, modify the activities and create their own IBSE activities for use in gardens or outdoor spaces. This proved to be a valuable process resulting in increases in positive attitudes towards IBSE, confidence using IBSE and changes to teachers' teaching practices. The enthusiasm for inquiry-based approaches instilled within the INQUIRE courses also led to increased levels of science learning outside, with many examples described or presented in both portfolios and at the INQUIRE conference. Participation in the professional development also led to institutional-wide changes to education provision and practice and increased professional development of educators in the gardens and museums.

Similarly, choosing a content area such as biodiversity and climate change was opportune as it addressed a knowledge gap for many participants.

While running the courses, differences were noted between various course participants that had implications for future course design.

For instance, it might be necessary in some instances to design separate courses for teachers and educators or for primary and secondary school teachers owing to differing needs.

In terms of Guskey's model of professional development, this accounted for level 1 impact: that is, participants were satisfied with the course and reactions to it were positive.

Participation in INQUIRE courses led to increased engagement with outdoor learning environments, since many teachers had never before visited a botanic garden.

Data Sources			
Interviews	Semi-structured interviews	Interviews exploring reflective practice, evaluation and progress with PIC course implementation	Semi-structured interviews after pilot inquire course as a formative discussion about feedback and evaluation
	Semi-structured interviews	Interviews exploring reflective practice, evaluation, issues with final course implementation and personal gains from taking part in the project	Semi-structured interviews after final inquire course as a discussion of the course evaluation and outcomes from the project
Artifacts	Materials from partner meetings	Posters outlining plans for course structure, evaluation, lesson and session plans	To assess how partners have modified their materials to develop IBSE lessons in LOtC setting, in response to support and evaluation
	Other artefacts from project planning and reflection	Additional artefacts such as documents prepared as part of project tasks and deliverables	Provide insights into the reflective cycle processes, the development of a shared understanding of IBSE, the contribution to the community of practice and the professional learning
Portfolios of evidence	Evidences are collections of artefacts that show partners' work and participants' learning	Provide a written commentary that explains the role of the artefacts and the evidence of course evaluation	Provides insights into critical reflection, professional learning and influences of the course

Data Sources			
Fieldnotes	Fieldnotes from support visits, partner meetings and INQUIRE conference	Descriptions of events	Provide additional data to explore the design, implementation and evaluation of the INQUIRE courses
Project Deliverables	Submitted deliverables to the EU as part of the project	Monitoring the implementation of the INQUIRE project	Provide additional data to explore the design, implementation and evaluation of the INQUIRE courses

Table 1. Description of data sources

As a result of the courses, they learned to be comfortable with the botanic garden as an outside space for learning and to develop their own investigations using gardens and outdoor spaces.

Because the courses addressed some of the common misconceptions about IBSE, such as '*doing hands-on science is the same as inquiry*' or '*you needs lots of time to do IBSE*' or '*you can't assess inquiry*', the course participants themselves felt that their knowledge and practice increased. In addition to theoretical pedagogical and subject knowledge gains (biodiversity and climate change), confidence in using IBSE and reflective practice techniques also increased. However, the INQUIRE partners, despite showing increased use of evaluation tools in their assessment of participants' learning, continued to require additional support to determine whether or not their learning outcomes had been achieved in their courses in order to improve their ability to articulate with the evidence. Partners often described their views of participant learning in terms of their intended learning outcomes for the courses rather that what participants' actually did learn. Furthermore, in the portfolios, many partners struggled to link their judgments to artefacts that provided evidence for the judgment.

In terms of Guskey's model of professional development, this accounted for level 2 impact: that is, the teachers and educators learned new knowledge and skills.

Changes to science teaching practices were observable in many partner institutions and within the participants' practices in their schools and gardens, such as altering existing lesson plans for their school groups to make them more open and IBSE focused, or devising new lesson plans that focused specifically on both an inquiry-based approach and biodiversity/climate change topics. The botanic gardens as organisations also demonstrated significant changes in terms of staffing, provision for public engagement, as well as educational programmes and their whole educational offer.

In terms of Guskey's model of professional development, this accounted for level 3 impact: that is, support was offered by both botanic gardens and schools for participants.
The result here was organisational change in botanic gardens and changes in teaching practices for teachers in schools. It also demonstrated level 4 impacts because both teachers and educators implemented their new knowledge and skills in the classroom and garden contexts.

For students, interest and engagement with science in botanic gardens was increased using IBSE activities through the development of scientific process skills such as observation, critical thinking, asking questions, and developing hypotheses, and social abilities such as listening and debating. Students also showed increased understanding of issues of biodiversity and climate change. In terms of increasing student learning outcomes from IBSE activities in outdoor spaces, practitioners should realise that students required support with making connections and using terminology during IBSE activities.

> *The level of evidence for student learning outcomes, or Guskey's level 5 impacts, is not as strong as the previous levels, however, instances of effect on affective, as well as cognitive outcomes, have been offered by the teachers' and educators' own reflective practice or practitioner research on the implementation of IBSE with their class.*

Although the project could report very positively in terms of participant's views and learning from the courses and student learning outcomes as a result, providing teacher-training courses in botanic gardens was not without its difficulties. Fostering IBSE teacher-training provision in botanic gardens involved overcoming many barriers and challenges including the recruitment of participants, engaging in online participation, local educational and political contexts and bureaucracy, the absence of relevant IBSE literature in some languages and the persistence, in European contexts, of known barriers to outdoor learning.

Outlook & reflection

The INQUIRE project offered a significant contribution to education provision across Europe through the introduction and fostering of IBSE in both formal and informal settings on a large scale. This approach offered numerous opportunities for the successful cascading of best practice IBSE and LOtC pedagogical approaches in both the courses that were offered and as a result of extensive networking and dissemination. The INQUIRE courses constituted front-line support to teachers and informal educators interested in engaging with IBSE in their practice, and represented the bridging of the gap between informal science educations, formal science educators and educational researchers. Consequently, a key network of educators, teachers, teacher trainer, researchers and key educational and political stakeholders was established and considerable revival activity and discourse was achieved within each country. The net result of this three-year project was strong evidence for successful implementation of curriculum based innovations, ultimately making a strong case for both IBSE in LOtC settings. The project provided concrete examples of what IBSE looks like in practice in LOtC settings.

References

Dillon, J., Rickinson, M., Teamey, K., Morris, M., Choi, M. Y., Sanders, D., & Benefield, P. (2006). The value of outdoor learning: evidence from research in the UK and elsewhere. *School Science Review, 87*(320), 107–110.

Guskey, T. R. (2000). *Evaluating Professional Development*. Thousand Oaks, CA: Corwin Press.

Hatton, N., & Smith, D. (1995). Reflection in Teacher Education: Towards Definition and Implementation, *Teaching and Teacher Education, 11*(1), 33–49.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative Data Analysis: An expanded Sourcebook*. Los Angeles, CA: Sage Publications.

Rocard, M. (2007). *Science Education NOW: A renewed Pedagogy for the Future of Europe,* Brussels: European Commission. Retrieved from: http://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf (24.05.2014).

6.7 STENCIL: Science Teaching European Network for Creativity and Innovation in Learning

Francesca Magrefi – Amitié, Italy

Abstract

STENCIL is a Comenius Network funded with support from the European Commission within the Lifelong Learning Programme for a period of three years (2011–2013). STENCIL includes 21 members from nine European countries who are working together to contribute to the improvement of science teaching, by promoting innovative methodologies and creative solutions that make science studies more attractive for students. STENCIL offers to practitioners in science education from all over Europe, a platform, the STENCIL web portal – www.stencil-science.eu – to encourage joint reflection and European co-operation, also offering high visibility to schools and institutions involved in Comenius and other European funded projects in science education. STENCIL takes advantage of the positive results achieved by the former European projects STELLA – Science Teaching in a Lifelong Learning Approach (2007–2009) and GRID – Growing interest in the development of teaching science (2004–2006). STENCIL main objectives are 1) to identify and promote innovative practices in science teaching through the publication of Annual Reports on Science Education, 2) to bring together science education practitioners to share different experiences and learn from each other through the organisation of periodical study visits and workshops and 3) to disseminate materials and outcomes coming from previous EU funded projects, and from isolated science education initiatives, through the STENCIL web portal, as well as through international conferences and national events.

The STENCIL Network

The context

With a growth of over 37% in the number of MST graduates in 2000–2008, Europe already exceeded the benchmark of the 15% to be reached by 2010. But a new challenge has been already launched with the 2020 benchmark to reduce the percentage of low-achieving 15-year-olds in reading, mathematics and science literacy to less than 15%. At the same time, a worrying shortage of qualified teachers has been reported in almost all countries, with the 14% of all pupils taught in schools where instruction is hindered by the lack of qualified teachers (European Commission, 2011). The link among the way science is taught at school and the interest of young people in science studies and carriers has been highlighted by Rocard (2007) and the enhancement of the professional profile of teachers is one of the overall priorities identified by the Cluster 'Mathematics, Science & Technology' (MST)', together with modernising pedagogical methods, promoting partnerships between schools, universities and industry, improving female participation in MST studies and careers, addressing needs of special groups and ensuring transitions from secondary to tertiary. "Improving the quality of teacher education" is still a priority for Europe and in the European Commission Communication with this title, the teacher profession is described, among the other characteristics, as a mobile profession based on partnership (European Commission, 2007). STENCIL–Science Teaching European Network for Creativity and Innovation in Learning, funded with support from the European Commission within the Lifelong Learning Programme, goes exactly in this direction, as it wants to contribute to the improvement of science teaching by encouraging joint reflection and European co-operation among teachers and schools from all over Europe.

The Network

The STENCIL Network includes 21 members from nine European countries: Bulgaria, Germany, Greece, France, Italy, Malta, Portugal, Slovenia and Turkey. To involve organisations and schools from such a high number of countries represents a great benefit for STENCIL, whose aim is to contribute to the improvement and innovation of science teaching in Europe. This is not only true at geographical level but also considering that the STENCIL partners represent different points of view on science education as they are: public and academic research institutes, private research organisations, science museums, educational authorities and schools.

A positive and fruitful cooperation represents the basis on which the STENCIL Network is built and run. Part of the STENCIL partners are partners in the STELLA project and thus have successfully cooperated in the past, namely: the coordinator, Amitié (IT), the University of Lorraine, formerly called Institut National Polytechnique de Lorraine (FR), the Regional Directorate of Education in Madeira Region (PT), the Institute for Innovation in Learning of the Friedrich-Alexander-University of Erlangen-Nuremberg (DE) and the Private Vocational School for Multimedia, Computer Graphic Design (BG). Starting from this core group, new research organisations, schools and institutions have joined: they are willing to bring their experience in science education to the STENCIL Network. Each partner, in fact, is bringing to STENCIL a specific point of view on science education, as well as specific competences and connections with the science education sector.

With the aim to enlarge the Network and to ensure its sustainability during the next period, STENCIL partners have carried out an intense activity aimed at involving new members in the partner countries and all over Europe. An associate partner agreement has been defined, setting up the terms of the cooperation with the new associate members, mainly consisting of mutual dissemination, exchange of information and resources. By the end of 2013, already 33 new associate members coming from different countries have been involved, including important institutions and organisations, either from European and non-European countries, such as the Technion – Israel Institute of Technology (Israel), the Italian General Consulate, Melbourne, Australia – Education Department (Australia), the Department of Physics and Astronomy – Alma Mater Studiorum – Università di Bologna (Italy), the l'Istituto Nazionale di Geofisica e Vulcanologia (INGV), and many other schools, enterprises, associations, etc.

Project objectives

STENCIL wants to offer science teachers, schools, school leaders, policy makers and all practitioners in science education from all over Europe, a web platform – www.stencil-science.eu – with the aim to encourage joined-up thinking and European cooperation. The concrete objectives of the STENCIL Network are the following:

- To identify, evaluate and promote innovative practices in science teaching, by publishing three Annual Reports on the State of Innovation in Science Education;
- To bring together science education practitioners to share different experiences and learn from each other by organising study visits and workshops, in a peer to peer approach;
- To disseminate materials and outcomes coming from previous EU funded projects, but also from isolated science education initiatives, through the STENCIL web portal and events, including the international conferences;
- To provide educational authorities and policy makers with a set of Guidelines and a Manifesto for innovating science education in their countries.

The Stencil web platform represents one of the main outcomes of the STENCIL Network and is a powerful tool to involve teachers and schools and all science education practitioners in a fruitful exchange of ideas and practices. All these target users are actively taking part in the STENCIL Network in different ways:

- by publishing their science education projects and searching for initiatives within different subjects from other schools and countries, among the over 1 200 included in the STENCIL European online Catalogue of science education initiatives: http://www.stencil-science.eu/catalogue.php
- by suggesting content for the European and

National Communities of Practice: http://www.stencil-science.eu/communities.php
- by applying to the STENCIL Calls for Participants with their initiatives: http://www.stencil-science.eu/call_for_participants.php
- by attending the STENCIL events or alternatively, going through the multimedia documentation available on line: http://www.stencil-science.eu/study_visits_workshops.php

All STENCIL outcomes have been conceived to promote a European dimension in science teaching and to contribute to overcome the prevalent thinking in terms of isolated projects. STENCIL in fact provides teachers and schools with a "picture window" on science education in Europe, giving them the opportunity to open the classroom and casting a glance out of the school walls, as an important step for reflecting and innovating their consolidated ways of teaching.

Project approach

The STENCIL project was designed on the positive results of two former European projects: STELLA – Science Teaching in a Lifelong Learning Approach and GRID – Growing interest in the development of teaching science.

The STELLA project – http://www.stella-science.eu – has been funded with the support from the European Commission within the Lifelong Learning Programme, in 2008–2010. It aimed at contributing to the improvement of science teaching in European schools. The STELLA eBook "Science Education in European Schools – Selected Practices from the STELLA Catalogue" illustrated selected practices identified from the STELLA Catalogue of Science Education Initiatives. The STELLA project gained excellent results, and it continued the work done in the former European project GRID by enriching and further developing the Online Catalogue of Science Education Initiatives already created in this framework.

The GRID project (2004–2006), funded within the framework of the EU Socrates Programme, had the objective of creating a network for the exchange of good practice in the field of science teaching in Europe, at the level of decision-makers and schools. In this frame, an international survey was carried out to identify policies and innovative initiatives all over Europe, the results of which have been made accessible through two online catalogues which included respectively more than 500 initiatives and 70 reports and recommendations on subjects related to science education.

STENCIL represented the logical and natural development of the former STELLA and GRID projects. It started from these results to go a step further, involving directly, as full members, the target groups of the previous projects, giving them the possibility to meet and learn from each other and from other key players in science education. One of the main STENCIL objectives was the identification of good practices in science education, which have been carried out at two different levels:

- *Quantitative level*, through the European Online Catalogue of Science Education Initiatives, that makes available to users more than 1 200 initiatives from different EU countries, on different subjects, directly submitted by teachers and persons in charge of the activity.
- *Qualitative level*, through the STENCIL Annual Reports, that describe a number of good practices selected by partners among the initiatives included in the Catalogue, according to a common set of criteria and some thematic areas. The Reports also include experts' reflections and recommendations, as well as teachers' reflections and feedbacks.

In order to attract more participants to the STENCIL community two *Calls for participants* have been launched, respectively on February 2012 and 2013, inviting teachers, educators and all professionals to submit their science education initiatives. From all the initiatives submitted, the STENCIL partners selected six innovative practices and awarded them with a grant for attending the international conferences or with a kit of science education materials to be used in classrooms of their choice.

STENCIL results

Outcomes and products

The STENCIL web portal – www.stencil-science.eu – is the most important product of the project as it makes all the outcomes and results achieved available, for free downloading, to the public at large.

The web portal is available in nine languages: Bulgarian, German, English, French, Greek, Italian, Slovene, Portuguese, and Turkish. It has different sections, including the *European and National Communities of practice,* respectively in English and in the national languages, which represent virtual spaces for the exchange on practices in science education from all over Europe.

All the STENCIL public outcomes are accessible from the STENCIL portal, namely:

European Online Catalogue of Science Education Initiatives – http://www.stencil-science.eu/catalogue.php: including more than 1 200 initiatives directly submitted online by teachers and schools from all over Europe, by filling in an online questionnaire which documents the key elements of the practice. STENCIL Catalogue offers to teachers and all persons interested in science education the possibility to publish their science education projects and to get inspired by searching for initiatives within different subjects from other schools and countries. The STENCIL Catalogue includes also initiatives from the former projects STELLA and GRID.

STENCIL Annual Reports titled *"Enhancing Innovation and Creativity in Science Teaching"*: published at the end of 2011, 2012 and 2013: they include the results of the joined-up thinking on current science education policies and trends by the STENCIL partners, as well as a number of innovative practices at national and European level.

The Report 1 (2011) approached science education from the outlook of national policies, reporting different expert positions on teacher training, collaborative and new pedagogical approaches, development of key competence and gender/diversity themes. http://www.stencil-science.eu/documents/annual_reports/STENCIL_AnnualReport1.pdf.

The Report n. 2 (2012) focused on practices that pertain to the themes "Teachers of the future: innovation in teacher training," "Science class in the era of ICTs and new technologies" and "Equality for Excellence" and demonstrate new pedagogical methods and strategies that could be embedded in EU national educational systems to enhance motivation and excellence in science education for all. http://www.stencil-science.eu/documents/annual_reports/STENCIL_AnnualReport2.pdf.

The Report n. 3 (2013) discussed current research initiatives and innovative practices, under the scope of making explicit practitioners' voice to the policy and researchers' calls for innovation and creativity in science teaching. http://www.stencil-science.eu/documents/annual_reports/STENCIL_AnnualReport3.pdf.

Study Visits & Workshops have been regularly organised to schools and other institutions in order to illustrate good and innovative practices in science education. For all these events, multimedia documentation (including videos, photos and documentation) have been made available online at: http://www.stencil-science.eu/study_visits_workshops.php.

STENCIL international conferences took place at the end of 2011, 2012 and 2013 respectively, in Nancy – France, Kassel – Germany and Bologna – Italy, involving teachers, school managers and policy makers at regional, national and European level. International conferences represented an important occasion to make visible the STENCIL results, but also to share and disseminate relevant projects and experiences in science education from other countries and at European level. Multimedia documentation and resources related to these events were published on the dedicated web page of the STENCIL portal: http://www.stencil-science.eu/international_conferences.php

STENCIL Guidelines for teaching and learning science in creative ways provides all relevant actors in science education, at all school levels with a set of suggestions and recommendations on how to achieve innovation and creativity in teaching, starting from the analysis of the way science teaching and learning innovation is improved and perceived in the European schools. http://www.stencil-science.eu/documents/guidelines/STENCIL_Guidelines.pdf

STENCIL Manifesto presents, in a short and visual way, the five recommendations for Teaching and Learning Science in creative ways, which are included in the Guidelines. The Manifesto is available online in nine languages and printed and distributed, 100 copies per country. http://www.stencil-science.eu/documents/guidelines/STENCIL_Manifesto_EN.pdf

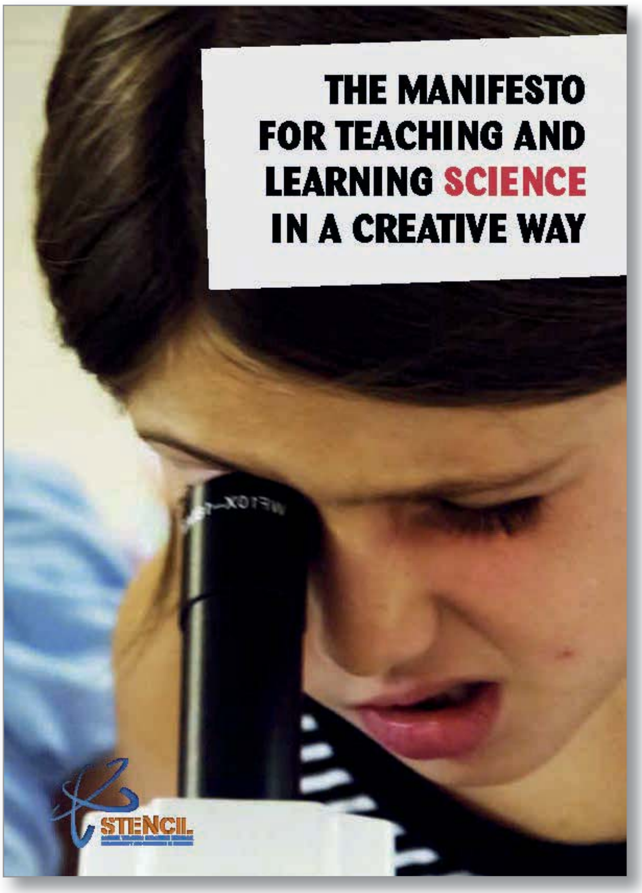


Figure 1. STENCIL Manifesto

Future perspectives

The Comenius STENCIL project has come to an end in December 2013. In order to make sure that the project results don't die with the end of the project, the partners have committed themselves to maintain the STENCIL web portal online and "alive" to serve as a tool for communication and exchange of good practices among schools and teachers from all over Europe.

The STENCIL *Guidelines and the Manifesto for teaching and learning science in creative ways* have been distributed in all partner countries to boost the impact of the project on science education, by stimulating and encouraging future innovative initiative. In this regard, the *five recommendations* included in the Guidelines and Manifesto, and derived from the analysis of the STENCIL outcomes and results, represent a driving factor for future projects and initiatives:

Recommendation #1: New methods and investigation tools should be designed for collecting comparable data across Europe and deeply investigating the nature of the gap between research and school practice in various contexts. Initiatives and activities that can bridge this gap, especially the participation of teachers and schools in European projects on science education, should be encouraged as well.

Recommendation #2: Good practices focused on IBL should be disseminated with the aim to show how the current science curricula can be improved in order to make the most of the motivational, cultural and social potential offered by IBL. Science Education Researchers, together with school teachers, should investigate the reasons why IBL was still struggling to establish itself.

Recommendation #3: Activities and projects aiming to revise traditional curricula should be boosted and supported in order to make the most of the ICT educational potential, as well as the adoption of ICT based teaching materials. Teachers should be encouraged to explore ICT tools and be free to change their school practices consequently.

Recommendation #4: Communities of practice of teachers, teacher trainers, researchers and stakeholders should be promoted by the educational authorities. Effective and sustainable communities of practice were recommended to be designed with specific and shared educational aims. Such aims should include and respect the local socio-cultural context of the school.

Recommendation #5: Initiatives and actions aiming to spread the perception of how and why the gender & minority issue effected the social impact of science should be encouraged and supported and, vice versa, how science teaching, even implicitly, impacted on the social issue of gender & minority. Experiences in schools that proved effective in: i) stimulating the interest of girls in science and scientific careers, ii) fostering inclusiveness, should be spread.

With these suggestions in mind, STENCIL partners are planning to submit new initiatives at European level, as well as to find national form of support to continue working together.

References

European Commission. (2011). *Progress towards the common European objectives in education and training (2010/2011)* – Commission Staff Working document. Retrieved from: http://ec.europa.eu/education/lifelong-learning-policy/doc2881_en.htm (14.06.2014).

Rocard, M. (2007). *Science Education NOW: A renewed Pedagogy for the Future of Europe*. Brussels: European Commission. Retrieved from: http://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf (14.06.2014).

European Commission. (2007). *Improving the Quality of Teacher Education – Communication from the Commission to the Council and the European Parliament*. Retrieved from: http://ec.europa.eu/education/com392_en.pdf (14.06.2014).

Acknowledgement

The STENCIL project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

6.8 Ark of Inquiry: A European Project for the Widespread Dissemination of Inquiry Activities through a Network of Universities, Schools, Science Centres and Museums

Margus Pedaste, Leo Siiman & Mario Mäeots – University of Tartu, Estonia
Bregje de Vries – HAN University of Applied Sciences, Netherlands
Zacharias C. Zacharia & Marios Papaevripidou – University of Cyprus, Cyprus
Tomi Jaakkola – University of Turku, Finland
Sofoklis Sotiriou & Georgios Mavromanolakis – Eellinogermaniki Agogi, Greece

Abstract

The Ark of Inquiry project aims to raise youth awareness to Responsible Research and Innovation (RRI) by providing young European citizens (7 to 18-year-olds) with a pool of engaging inquiry activities. The project will 1) develop a framework for identifying inquiry activities that promote pupils' awareness of RRI; 2) collect existing inquiry activities and environments from various national and international projects; 3) make the activities available across Europe through the Ark of Inquiry platform in order to bring together inquiry activities, learners, and supporters (teachers, science and teacher education students, and staff of universities and science centres); 4) train at least 1 100 teachers to support pupils' inquiry activities in a manner that attracts pupils' interest and motivation towards RRI; and 5) implement the inquiry activities on a large-scale across a European school network.

Project description

The Ark of Inquiry project (http://arkofinquiry.eu/) is a project funded by the 7th Framework Programme of the European Commission within Activity 5.2.2 Young People and Science. Our general goal is to initiate a change in youth awareness of Responsible Research and Innovation (RRI) and we intend to achieve this by applying an inquiry-based science approach. This project supports the building of a scientifically literate society which will better enable European citizens to participate in the research and innovation process.

The Ark of Inquiry project started in March 2014 and ends in February 2018. The project aims to provide young European citizens (7 to 18-year-olds) with a pool of engaging inquiry activities to improve their inquiry skills, increase their awareness and understanding of conducting 'real' science, and prepare them to participate in RRI processes.

The Ark of Inquiry consortium of 13 partners is coordinated by the University of Tartu (Estonia) and includes partners from 12 different countries: Ellinogermaniki Agogi, Research and Development Department (Greece), University of Turku, Centre for Learning Research (Finland), University of Cyprus (Cyprus), The United Nations Educational, Scientific and Cultural Organization, Regional Bureau for Science and Culture in Europe, Venice (Italy), HAN University of Applied Sciences, Research Centre Quality of Learning (Netherlands), Austrian Bundesministerium für Bildung und Frauen (Austria), Humboldt-Universität zu Berlin (Germany), Bahcesehir Egitim Kurumlari Anonim Sirketi (Turkey), Ecole de l'ADN – Nîmes European DNA Learning Centre (France), Katholieke Hogeschool Limburg (Belgium), Hungarian Research Teachers' Association (Hungary), AHHAA Science Centre (Estonia).

The Estonian, Finnish, Dutch, and Cyprus partners have lead roles in developing the *pedagogical framework* of the Ark of Inquiry. In addition, the University of Cyprus is leading the development of the *teacher training* approach and the University of Tartu is in charge of project *evaluation*. The Greece centre and UNESCO office in Italy are responsible for building up an Ark of Inquiry *community* and *disseminating* our ideas and outcomes. The Hungarian, Turkish and French partners represent schools and the AHHAA science centre supports us in involving the community of science centres and museums. The Austrian ministry is important for disseminating ideas but also for supporting further engagement of policy makers in Europe.

The Ark of Inquiry project is organized into eight work packages: Pedagogical framework, Collection of inquiry activities and environments, Supporting community, Training, Evaluation, Implementation, Dissemination, and Project management. The expected outcomes are described through four milestones: Ark of Inquiry principles by the end of the first year, piloting results in month 18, validation of the training and dissemination platform of inquiry activities by the end of the second year, and Ark of Inquiry exploitation at the end of the project.

Pedagogical approach

Traditional science education tends to emphasize a 'top-down transmission' approach, where a teacher first lectures about concepts, deduces implications from these abstract notions and then gives examples of applications. In contrast, inquiry-based science education relies on a 'bottom-up' approach, where learners first experience concrete problems, are curious to find solutions to these problems, are willing to experiment and tolerate failure to find answers, and are guided to cumulatively construct an understanding of the fundamental principles explaining scientific phenomena. As emphasized in the report 'Science Education Now; A renewed pedagogy for the future of Europe' (Rocard et al., 2007), inquiry-based learning has proven to be effective in stimulating interest in science. Several review studies also confirm that inquiry-based learning is more effective in achieving better learning outcomes when compared to "traditional" learning approaches such as direct instruction (Alafieri, Brooks, Aldrich & Tenenbaum, 2011; Carolan, Hutchins, Wickens & Cumming, 2014; d'Angelo et al., 2014; Furtak, Seidel, Iverson & Briggs, 2012). Therefore, if implemented more widely, inquiry-based methods promise to equip future researchers and other societal actors with the necessary knowledge and tools to fully participate and take responsibility in the research and innovation process.

However, despite the proven success of inquiry-based science education and the learning environments developed to improve students' inquiry skills (see de Jong et al., 2010; Pedaste et al., 2013; Pedaste & Sarapuu, 2006; Pedaste & Sarapuu, 2014) there are still some issues in applying inquiry learning more widely in everyday learning. One of the reasons could be the complexity of selecting and working through an inquiry cycle in order to develop inquiry skills.

Pedaste et al. (submitted) reviewed over 100 different terms found in contemporary educational literature to describe various inquiry processes (e.g. observe, identify the problem, predict, investigate, find patterns, analyse, organize the data, draw conclusions, discuss, reflect, etc.). The authors then synthesized a simplified inquiry learning cycle framework to highlight which activities are conceptually distinct and fundamental to inquiry. Their five distinct inquiry phases (Orientation, Conceptualisation, Investigation, Conclusion, and Discussion) and a number of sub-phases (Questioning, Hypothesis Generation, Exploration, Experimentation, Data Interpretation, Reflection, and Communication) form the core for the pedagogical approach taken in the Ark of Inquiry project.

Framework for inquiry proficiency

In the Ark of Inquiry project we will create a system to describe inquiry proficiency across three levels. A useful starting point to consider is the Common European Framework of Reference for Languages (2001). This internationally recognized system provides 'can do' descriptors to help learners self-assess their level of proficiency and divides language learners into three broad levels (A, B, and C), corresponding respectively to basic speaker, independent speaker and proficient speaker. The main dimension that determines proficiency is based on how well a speaker can achieve everyday goals. In a similar way, a system for inquiry proficiency was developed to distinguish inquiry levels: A (basic inquiry), B (advanced inquiry) and C (expert inquiry). The levels indicate how well a student can accomplish inquiry-based science.

To create a system of inquiry proficiency according to these levels, we identified two dimensions for developing inquiry proficiency (Table 1): (1) Self-regulation/self-directed inquiry learning, and (2) Awareness of Responsible Research and Innovation. *Self-regulation* refers to how much control over the inquiry learning process is given to the learner. In terms of inquiry proficiency, the learner self-direction dimension divides into three levels according to whether inquiry activities are mainly teacher-led (A level), teacher-guided (B level) or student-led (C level). At the A level the inquiry activities are predefined by the teacher and/or the materials, and are aimed at teaching learners how to conduct research. At the B level the inquiry activities are ill-defined but take place in a predefined problem space that sets the limits for the research. The main goal here is to teach learners what to investigate and guide them towards independency related to knowing how to inquire. At the C level students need to develop a research activity in an ill-defined problem space or complex societal context, and learn when to inquire and how to reflect as well as discuss outcomes in collaboration with stakeholders.

A second dimension to determining inquiry proficiency is *RRI awareness*. RRI awareness stands for the awareness of the relevance of research and research findings to people and society, as well as the responsibility to apply research and research findings in a balanced and respectful way in relation to the three pillars of sustainability: People, Planet and Profit (e.g. Slaper & Hall, 2011). Students advance in inquiry by gradually expanding this awareness. For example, beginners are presented with predefined inquiry activities and learn to report and present their findings according to a worksheet or fixed presentation format, whereas students at the B and C level are expected to respectively present their findings and communicate about it in a semi-structured format and interactive mode, or discuss their findings with others in order to relate it to societal applications and reflect via the Discussion inquiry phase. Discussion in this case refers to communicating and reflecting on inquiry.

The evaluation of inquiry proficiency

The Framework for Inquiry Proficiency will form the base for an evaluation system through which teachers and students can follow and assess the progression in inquiry. The evaluation system will be built on three theoretical starting points. First, it shares a view on learning as personal. Personalised learning “recognizes that the quality

Inquiry Phase	Inquiry Level		
	A (basic inquiry)	B (advanced inquiry)	C (expert inquiry)
ORIENTATION	Teacher-led	Teacher-guided	Student-led
CONCEPTUALISATION			
INVESTIGATION	Predefined problems	Ill-defined problems in a predefined problem space	Ill-defined problems in ill-defined problem space
CONCLUSION			
DISCUSSION	Aimed at skilfulness Learning to report and present	Aimed at independency Learning to communicate	Aimed at interdependency and societal relevance Learning to discuss and reflect

Table 1. The Ark of Inquiry Framework for Inquiry Proficiency

of learning is shaped by learners' experiences, characteristics, interests and aspirations" (Pollard & James, 2004). Choices in the process of learning should hence be tailored as much as possible to the needs of learners. One of the key components of personalised learning is assessment *for* learning in which evaluation is mainly formatively aimed at identifying the learner's next needs. Second, the evaluation system views inquiry learning as a process that develops towards increasing self-regulation and intrinsic motivation (e.g. Boekaerts, Pintrich & Zeidner, 2000). At the C level a student can effectively apply self-regulatory skills such as setting goals, inventing new task strategies, and organizing an inquiry activity. And third, the evaluation system seeks to effectively apply forms of peer and expert feedback. To give users of the Ark of Inquiry the sense that they become members of a larger community of researchers, the evaluation system will use evidence from moments of feedback/assessment by peers (for instance fellow students in the Ark of Inquiry) or experts (for instance scientists). Peer feedback or assessment is claimed to be contributing to learning both from the perspective of the receiver as well as the giver of feedback (e.g. Liu & Carless, 2006; McDonald & Boud, 2003). In short, the three starting points for the evaluation system – personal and formative assessment, increasing self-regulation, and peer feedback – strengthen the definition of inquiry learning at the three levels described above.

Teacher training and Ark of Inquiry community

In implementing the Ark of Inquiry pedagogical approach we have to select a vast number of inquiry activities that have been successfully applied in Europe or in particular countries. These are planned to be collected into the Ark of Inquiry platform. The platform will facilitate learning by recommending inquiry activities according to learners' personal characteristics (e.g. inquiry experiences and skills) and offers learning support to the community of peers (in order to conduct group activities and practice scientific communication). Especially important here is the community of teachers to ensure sustainable implementation of the Ark of Inquiry in school programmes across Europe. Therefore, we will provide rigorous face-to-face training for teachers to support their pupils' engage with Ark of Inquiry activities.

For teacher training we will develop materials that will include an introduction to the pedagogical approach, and in face-to-face training sessions allow teachers to experience a sequence of activities of the Ark of Inquiry as learners. Prior research (e.g. Clarke & Hollingsworth 2002; Crawford 2005; de Jong, Van Driel & Verloop 2005; Justi & Gilbert 2005) indicates that positioning teachers in the role of active learners and letting them experience themselves the same learning journeys that their pupils are expected to follow could be beneficial for their professional development in several ways. In our case, teachers as learners will be given the opportunity to inquire for themselves (i) what they know and what they do not know about enacting inquiry, (ii) what type of skills or abilities need to be applied for enacting inquiry, and (iii) what epistemic considerations they need to make for assessing the validity of the acquired knowledge about inquiry and the process that has been followed for the development of this knowledge (that is their epistemic understanding status). In short, situating teachers as learners will allow them to experience and become aware of the various types of learning difficulties (e.g. conceptual, procedural, epistemic) that their pupils might be confronted with during their exposure to Ark of Inquiry activities, and accordingly take them into consideration for the design of their latter instructional settings. Finally, teachers will appear more ready and confident in their own field of practice for scaffolding their pupils' learning pathways while involved in the Ark of Inquiry activities through their own robust proficiency of both the content and the inquiry pedagogy that they might developed as a result of their own experience in Ark of Inquiry activities.

Outlook and reflection

The Ark of Inquiry project started in March 2014. Thus, it's too early to evaluate and disseminate its outcomes. However, we have already started to build a community and share our visions in the countries involved, so that in due time the coordination and management of the Ark of Inquiry platform can be taken over by national coordinators (e.g. ministries of education) and the main role in collecting content (inquiry activities) and supporting learning processes (including feedback and awarding) can be easily performed by teachers and science centres. Final recommendations for policy makers as well as other stakeholders will be communicated at the Ark of Inquiry conference in the last year (2018) of the project.

Acknowledgement

This study was conducted in the context of project Ark of Inquiry: Inquiry Awards for Youth over Europe, which is funded by the European Union (EU) under the Science in Society (SiS) theme of the 7th Framework Programme (Grant agreement 612252). This document does not represent the opinion of the EU, and the EU is not responsible for any use that might be made of its content.

References

Alfieri, L., Brooks, P. J., Aldrich N. J., & Tenenbaum, H. R. (2011). Does discovery-based instruction enhance learning? *Journal of Educational Psychology, 103*, 1–18, doi: http://10.1037/a0021017

Boekaerts, M., Pintrich, P. R., & Zeidner, M. (Eds.). (2000). *Handbook of self-regulation*. San Diego: Academic Press.

Carolan, T. F., Hutchins, S. D., Wickens, C. D., & Cumming, J. M. (2014). Costs and benefits of more learner freedom: Meta-analyses of exploratory and learner control training methods. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 56*(9), 999–1014.

Clarke, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education, 18*, 947–967.

Common European Framework of Reference for Languages (2001). Strasbourg: Council of Europe, Language Policy Unit.

Crawford, B. A. (2005). A framework for enhancing pre-service teachers' knowledge of scientific inquiry and modelling. Paper presented at the V Conference of the European Science Education Research Association, Barcelona, Spain, 28 August – 01 September 2005.

d'Angelo, C., Rutstein, D., Harris, C., Bernard, R., Borokhovski, E., & Haertel, G. (2014). *Simulations for STEM learning: Systematic review and meta-analysis*. Menlo Park, CA: SRI International.

de Jong, O., van Driel, J. H., & Verloop, N. (2005). Pre-service teachers' pedagogical content knowledge of using particle models in teaching chemistry. *Journal of Research in Science Teaching, 42*(8), 947–964.

de Jong, T., van Joolingen, W. R., Giemza, A., Girault, I., Hoppe, U., Kindermann, J., . . . van der Zanden, M. (2010). Learning by creating and exchanging objects: The SCY experience. *British Journal of Educational Technology, 41*, 909–921. doi: 10.1111/j.1467-8535.2010.01121.x

Furtak, E. M., Seidel, T., Iverson, H., & Briggs, D. C. (2012). Experimental and quasi-experimental studies of inquiry-based science teaching. *Review of Educational Research, 82*, 300–329, doi: http:// 10.3102/0034654312457206

Justi, R., & van Driel, J. (2005). The development of science teachers' knowledge on models and modelling: Promoting, characterizing, and understanding the process. *International Journal of Science Education, 27*(5), 549–573.

Liu, N., & Carless, D. (2006). Peer feedback: The learning element of peer assessment. *Teaching in Higher Education, 11*(3), 279–290.

McDonald, B., & Boud, D. (2003). The impact of self-assessment on achievement: The effects of self-assessment training on performance in external examinations. *Assessment in Education, 10*, 209–220.

Pedaste, M., & Sarapuu, T. (2006). Developing an effective support system for inquiry learning in a web-based environment. *Journal of Computer Assisted Learning, 22*(1), 47−62.

Pedaste, M., & Sarapuu, T. (2014). Design principles for support in developing students' transformative inquiry skills in web-based learning environments. *Interactive Learning Environments, 22*(3), 309–325.

Pedaste, M., de Jong, T., Sarapuu, T., Piksööt, J., van Joolingen, W. R., & Giemza, A. (2013). Investigating ecosystems as a blended learning experience. *Science, 340*(6140), 1537–1538.

Pollard, A., & James, M. (Eds.). (2004). *Personalised Learning: A commentary by the Teaching and*

Learning Research Programme. London, UK: Economic and Social Research Council.

Rocard, M., Csermely, P., Jorde, D., Lenzen, D., Walberg-Henrikson, H., & Hemmo, V. (2007). *Science education now: A renewed pedagogy for the future of Europe*. Brussels: European Commission: Directorate-General for Research; 2007.

Slaper, T. F., & Hall, T. J. (2011). "The Triple Bottom Line: What Is It and How Does It Work?" *Indiana Business Review, 86*(1), 4–8.

6.9 Pri-Sci-Net – An FP7 EU funded Project Promoting Inquiry-based Learning in Science at Primary Level of Education

Suzanne Gatt – Malta Council for Science and Technology, Malta
Annette Scheersoi – University of Bonn, Germany
Demetris Koursis – University of Cyprus, Cyprus

The main challenge for Science Education is engaging learners in effective learning which lasts and provides them with knowledge, skills in science coupled with attitudes and values. Learning science from a book has long been recognised as being ineffective in promoting good learning in science, particularly at primary level where children are very curious to explore and learn how the world works. Learning science from books pushes students away from choosing science later on in their educational career choice. Traditional science teaching also does not equip students with the skills and competences necessary to become scientists. The European Commission (2007) has recognized this and advocates inquiry-based learning as the main pedagogy for teaching science. It is for this purpose that the European Commission has invested in supporting so many projects focused on promoting effective science teaching approaches focusing mainly on the use of the inquiry-based approach.

This paper presents the work done by FP7 project Pri-Sci-Net (grant no. 266647) and which aims to promote the uptake of inquiry-based learning approaches at primary level across Europe with children aged 3–11 years. The main project outcomes include developing a shared understanding of inquiry-based learning when relating to young children, helping teachers develop the required pedagogical skills, and to convince them to share their experience and resources with other teachers.

The paper shares the project partners' vision for inquiry-based learning, pedagogical material produced in inquiry-based learning and which teachers can use when teaching, the initiatives taken at national and international level to train teachers.

Pri-Sci-Net is an EU funded FP7 Supporting and coordinating action (Call SiS-2010-2.2.1.1) which focused on innovative methods in science education: teacher training on inquiry-based teaching methods on a large scale in Europe. The project is coordinated by the Malta Council for Science and Technology (MCST) from Malta and has 17 partners from 14 countries. The project started in September 2011 and is three years long. It comes to an end on the 31st August 2014.

The project includes initiatives to promote the inquiry-based learning approach to learning science among primary teachers teaching young children in the age range of 3–11 years. The overall aim is to set up a Europe-wide network of professionals and academics in the area of Primary Science Education. The training and professional support to teachers aims to help them use inquiry-based learning in science in schools. This support will be both in the form of national and international training courses as well as to bring together teachers from different countries to share their work. The project also recognizes teachers' and researchers' achievements through a Certificate of Excellence in the implementation of inquiry-based learning in science at primary level. The work of young researchers who focus on children's learning in science through inquiry is also recognised in the form of a Certificate of Excellence for research in inquiry-based learning. Further information about the project's activities can be obtained from: www.prisci.net. The pedagogical material produced can be obtained from www.priscinetwork.wordpress.com.

The project's vision for inquiry-based learning in science

The Pri-Sci-Net team, making up around 30 primary science educators from different European countries have worked together for these three years to develop and promote a vision for inquiry-based learning in science which they belief reflects an effective approach to doing science with young children. This vision was developed and agreed to by the project consortium in the first project meeting, and has been the basis of all the work carried out by the partners in the project.

In this Vision, the Pri-Sci-Net group believes that inquiry-based science at primary level is a *teaching and learning framework* with implications about learning science, learning to do science, and learning about science.

In this framework: *children*

- engage actively in the learning process with emphasis on observations and experiences as sources of evidence;
- tackle authentic and problem-based learning activities where the correctness of an answer is evaluated only with respect to the available evidence and getting to a correct answer may not be the main priority;
- practice and develop the skills of systematic observation, questioning, planning and recording to obtain evidence;
- participate in collaborative group work, interact in a social context, construct discursive argumentation and communicate with others as the main process of learning;
- develop autonomy and self-regulation through experience;

The teacher scaffolds and guides learning by providing a role model of an inquiring learner. The teacher does not function, in the eyes of the children, as the sole bearer of expert knowledge. Instead, the main role of the teacher is to facilitate negotiation of ideas and to highlight criteria for formulating classroom knowledge.

Assessment is mainly formative, providing feedback to the teaching and learning process for all classroom participants. All the activities promoting inquiry-based learning science within this project reflected this understanding on inquiry. As a framework, different specific pedagogical approaches can be adopted. However, each of the science activities used and shared had to reflect this vision.

Criteria for inquiry-based learning in science

Based on the vision, the project partners have developed a set of criteria which ensured that any science activity which was promoted by the project reflected the project's vision of inquiry. This was achieved through ensuring that activities included all the criteria for inquiry-based learning to different degrees. The criteria identified and developed are 8 and include the following:

1) Activities in science should be authentic:

In order for a child to solve a scientific problem, the problem needs to be authentic. This means that the problem needs to become the child's own problem, so that the child has the desire to solve it. The problem needs to have a meaning for the child, and the child has to take part in developing it, to whatever extent possible (Pollen, 2006). Therefore it is wise to choose a content area that falls within the cultural and physical environment of the child and to choose general objectives that are suited to children of the age group under consideration.

2) Stimulate the development of inquiry skills:

The Pri-Sci-Net activities need to stimulate the development of inquiry skills in children. Learning begins with a problem to be solved. In some cases, the activity can begin with a question. In this case the wording of the initial question is important. As all starting situations are intended to lead to the identification of a scientific problem, the problem needs to be posed in such a way that children have to interpret the problem, gather needed information, identify possible solutions, evaluate options and present conclusions. All starting situations are intended to lead to highlighting a problem and to attract attention. Inquiry-based Science Education is a problem-based approach but goes beyond it while also retaining the importance given to the experimental approach.

3) Activities need to stimulate the active engagement of children:

Knowledge and understanding need to be acquired actively. For this to happen children's curiosity must be raised and their interest must be stimulated. Learners must be actively engaged in the learning process. The term 'Actively' indicates that each step in the learning process has a specific purpose aimed at completing an activity or action. 'Actively' can thus refer both to: physical action, e.g. completing practical tasks; but also to cognitive action e.g. mental processes involving strategic thinking and critical reflection. It is not sufficient that learners can work practically during a science activity. In addition to the physical process, children also need to be active in terms of thinking. This aspect is considered vital to the success of any learning experience.

4) Inquiry science involves a strong element of observation:

There are many important science inquiry skills such as asking questions, making predictions, designing investigations, analyzing data and supporting claims with evidence. One of the most important skills, however, is that of being able to observe closely and systematically, as well as determining what it is important to observe. Children observe and react to many things and they also ignore many things just as adults do. In order to "see" something, you need to know what you are looking for. Often, children are simply told to observe something closely. But what does this mean? Many will need guidance to learn to link their observations to their ideas, beliefs or hypothesis. For example, being asked to observe two insects is very different from being asked to observe the insects and note the similarities and differences between them.

5) Inquiry involves considering and using observations as evidence for making arguments:

Observations made are a means of gathering evidence. Based on this evidence, children are to draw conclusions. Inquiry-based learning requires that children draw conclusions from the information which they have gathered and have to build an argument using this evidence. Inquiry activities need to require children, at some point, to consider their observations, whether direct or as a result of research and based on this evidence, to draw their conclusions. As much as possible, conclusions drawn must be presented with the evidence on which they are based.

6) Inquiry can only take place through collaborative group work:

The Pri-Sci-Net activities are designed to stimulate collaborative group work among children. Collaborative group work goes beyond working within a group but also means working effectively with peers. Activities should create opportunities for children to work with each other by taking different roles, dealing with and tolerating different opinions, sharing resources with each other etc., all in order to construct knowledge within a social setting. Whether children are doing experiments, carrying out investigations or discussing scientific issues, they should be working in groups. These situations create opportunities for children develop good social skills involved in collaborative learning. These skills range from expressing personal thoughts, ideas and emotions to the group through to dealing with peers or the teacher/other adults within the school setting.

7) Inquiry promotes discursive argumentation and communication – talking science:

For Pri-Sci-Net, inquiry activities need to stimulate children in talking science. Inquiry-based learning is sometimes understood to mean only hands on activity. In order for direct experience to lead to understanding, students need to read instructions, think about their hands-on work, as well as to discuss it thoughtfully with others, and also to write about it. Students' ideas and theories, predictions, ideas for designing an investigation, conclusions, all need to be made explicit, and shared and debated orally and in writing. In many cases, it is by trying to convey one's viewpoint that one finds answers to one's questions. And, the reverse is true as well. It is often in trying to explain something that one's lack of understanding becomes clear. For many children (and adults as well) talking comes first. Once something has been said, it can be written.

8) Self-regulation:

The Pri-Sci-Net activities, finally, also need to stimulate self-regulation within children. Inquiry promotes self-regulation with children because it stimulates active engagement in the learning process by using cognitive and problem-solving strategies and metacognitive strategies to monitor understanding (Dejonckheere, Van De Keere & Tallir, 2010). Cognitive strategies include a wide variety of individual tactics that students and teachers use to improve learning. Problem-solving strategies are more complex than cognitive strategies and focus on the development of a strategy or heuristic in order to solve a scientific problem (e.g. inquiry circle). Metacognition refers to knowledge of cognition and regulation of cognition (Schraw & Moshman, 1995; Dejonckheere, Van De Keere & Mestdagh, 2009). Knowledge of cognition refers to declarative, procedural and conditional knowledge. Regulation of cognition includes planning, monitoring and evaluation (Schraw, 2006). The level of support during science activities will depend on the experience and intellectual development of the children. As the children develop their skills and confidence they should increasingly carry out their own investigations, taking on the responsibility of learning on themselves. Therefore, in promoting the ability to 'learn how to learn' to inquiry, the teacher needs to:

- Identify the level of the inquiry skills of the children;
- Provide support and strategies to help the children to carry out their own investigations; as well as
- Give opportunities for experienced learners to do their investigations on their own.

For a teacher, opportunities should be created in order to stimulate inquiry skills such as systematic and close observation, questioning, predicting, hypothesis generation, planning, investigating, modelling, interpretation of data, communicating and explaining findings to peers. It is really important for a teacher to help the children learn how to identify and state a problem, as science is built on problems that needs to be solved, and not just on observation alone.

Therefore, overall, teachers should develop inquiry-based activities where they challenge children by asking productive (process) questions in order to promote further learning and by encouraging the children to focus on strategies in order to solve the problem (STIPPS, 2008). The teacher should involve children in planning their science activities where it is appropriate and assists them to regulate their behaviour within learning contexts so that they can gather information and respond effectively. The ultimate goal is to create more autonomy and self-regulation of the learner.

All the science inquiry-based activities promoted by the Pri-Sci-Net project were identified through a rigorous selection process whereby the activities were analysed in terms of how much they include all of these eight criteria just described. It was also ensured that any training organised by the consortium included activities for teachers which reflected all of these eight elements of inquiry. The vision and these criteria ensured that all the consortium partners promoted the same type of inquiry across Europe.

Pri-Sci-Net project outcomes

The project worked to achieve a change in teachers doing primary science through a number of actions aimed primarily at teachers and teacher educators and researchers. These envisaged actions included:

- *Development of 45 science teaching activities* using IBSE in 15 different languages. Based on the vision and on the criteria developed, all the project partners submitted a number of inquiry activities to be within the 45 activities that were to be further developed. A large number of activities which included over 100 examples were evaluated against the criteria and the best 15 for each of the age ranges: 3–5 years; 6–8 years; and 9–11 years were selected. Realising that it is not just a question of translation, the partnership also trialed a number of the activities in the different partner countries in order to identify any particular barriers that may arise in using an inquiry activity developed in one country to be used in another European country. It was only following the trialing in the partner countries that the activities were finalised, professionally designed and then translated. These activities are currently being uploaded in the following website: www.priscinetwork.wordpress.com.
  Table 1 shows the list of activities that have been included within each age subgroup. Teachers are encouraged to access, adapt and use parts of these activities as much as they wish.
- *A database* of primary teachers and researchers in primary science. The partnership have developed a mode of building a database through which they can contact teachers, learn about the project initiatives and to participate in the project's activities. An 'expression of interest' form was developed and used by the project partners to obtain contact details as well as permission by teachers to keep them updated about the project, the pedagogical materials that it has developed and is promoting, and other initiatives in primary science. This approach has been helpful in building a database which now already amounts to over 1 000 primary school teachers from all over Europe. An online newsletter was sent regularly to those teachers who are included in the project database. This ensures that teachers wishing to learn about primary science can have links to where to access relevant educational material;
- *Three international teacher-training courses*. The project also organised three international training courses focusing on promoting inquiry-based learning in science.
  The 1st International training course was held in Ústí nad Labem, Czech Republic, from the 28th January to the 1st February 2013. 25 teachers from eight different countries participated in the training course. The international training course was aiming to attract primary teachers who were interested to learn more about teaching science in the upper grades of the elementary school. The training course tackled Inquiry-based Learning in Science Education (IBSE) and elaborated on various types of teaching and learning approaches that could be utilised in the classroom environment. Furthermore, the course offered specific subject content training in several areas of the primary education curriculum. Participants were also guided to join the Pri-Sci-Net virtual platform for IBSE in primary science and use that to share their work with other teachers. The course included sessions about IBSE and the Pri-Sci-Net project. Also the teachers attended workshops in which they had the opportunity to participate (assuming the role of students) in inquiry-based activities, organized by the science educators involved in the project.

The 2nd International training course was held in Crete, Greece, from the 1st to the 5th of July 2013. 35 teachers from nine different countries participated in the training course. The second international training was mostly intended to address inquiry-based learning in science education (IBSE) with younger primary students, aged 3 to 7. The training commenced with a general introduction to the Pri-Sci-Net project, followed by a discussion on the meaning of IBSE in the context of primary level education. Next, there was a presentation of the IBSE activities that were developed by the project partners for ages 3 to 7. Finally, participants were given the opportunity to experience some of those activities but also to engage in the process of adapting such activities or even designing their own activities. Emphasis was given to the Pri-Sci-Net teacher platform and its potential to serve as medium that could facilitate interactions and the exchange of ideas and teaching materials among teachers interested in IBSE.

The 3rd international training course was held in Salzburg, Austria from the 17th to the 20th of February 2014. 30 teachers from 12 different European countries participated in the training course. The training course opened with a welcome speech by the Austrian Ministry of

Activities in the age range 3–5 years	Activities in the age range 6–8 years	Activities in the age range 9–11 years
1 Planting seeds	1 Air as matter	1 Winter comes to campus = Chromatography
2 Do plants grow in the dark?	2 Plants' response to changes in orientation	2 Practical exercise from statistics for young scientists
3 Playing with shadows	3 Animal responses to light and humidity	3 Pigment research
4 Soil	4 Sounds	4 Acidic, Neutral or basic?
5 Sky	5 Seed Spinners: exploring air resistance	5 Measurements
6 Snails	6 Magnetic Power	6 Acidic-Neutral-basic: find your indicator from nature
7 Magnets	7 Exercises for health	7 How much weight can paper hold
8 What is a plant	8 Body covering and insulation powers	8 Underwater vulcano
9 Soap bubbles	9 Materials/Change of state	9 the snail that prefers cabbage or lettuce
10 What is colour?	10 Biodiverity/discovering what animals live in	10 Water, icebergs and boats
11 Strong Walls	11 The world around us: shadows, day/night	11 the secret of the human body
12 Water	12 Botany: swelling pressure of seeds	12 Air, more than nothing – characteristics of air
13 Swing game	13 Ants	13 Archimedes Principle II (who is able to build the best boat)
14 Let's float	14 Seeds germination	14 Human Body and Robot Body
15 Flying Balloon	15 Senses and their interaction	15 Animal and Animat

Table 1. List of activities

Education. Then, the Pri-Sci-Net project coordinator, Prof. Suzanne Gatt, welcomed the participants and shared the vision of the project for inquiry-based learning in primary education. The training course involved a series of workshops and presentations about IBSE contributed by project partners. Among the training activities, there was a workshop on colours from Muğla (Turkey) and a workshop on change of state, focusing on water and ice from the University of Southampton (UK). There was also a workshop on how to organise a science fair, a workshop on the nature of science and a world café. Some of these training activities took place in the local science museum in Salzburg.

Figure 1. The 2nd International Pri-Sci-Net training course in Crete (Greece)

Figure 2. The 3rd International Pri-Sci-Net training course in Salzburg (Austria)

- *Two international conferences* in Cyprus and in Malta.
  The first conference was held as part of the ESERA conference in Cyprus 2013. The second conference was held 16th–18th July 2014 in Malta. The work of the second year was topped by the first international conference which was organised in Nicosia, Cyprus in September 2013. The conference was particular as it was organised as part of the European Science Education Researchers Association (ESERA) conference. Besides being the first project to be supported by the European Association, the conference provided teachers with the opportunity to share their work with science education researchers from all over the world. In addition, the teachers also had the opportunity to listen to researchers who study in detail and problematise classroom experiences which teachers experience every day. The conference thus placed the Pri-Sci-Net within the international science education community as it was also mentioned in the official conference opening address where the experience was considered as a positive one by ESERA and to be repeated for other projects in the future. Pri-Sci-Net was thus a first in achieving international recognition by ESERA!

The 2nd and the final international conference of the Pri-Sci-Net project was held in Valetta, the capital of Malta, between the 16th and 18th of July, in the historical Building of the Old University. Approximately 100 delegates from different countries of Europe attended the conference and engaged in: a) discussions on the implementation of inquiry based science learning education (IBSE) in primary and pre-primary schools, b) hands-on workshops that can be replicated in the classroom, c) sharing of experiences and best-practices, d) discussion on the amalgamation of informal and formal learning. The end of the conference essentially marked the completion of the Pri-Sci-Net project with the hope and the expectation that what has been achieved during the project could make a significant contribution to the training of teachers with respect of IBSE.

The conference included two keynote lectures by experts in the field. The first lecture by Prof. Constantinos P. Constantinou (President of the European Association for Research on Learning and Instruction – EARLI) was entitled “Do children have any need for science learning? What does existing research tell us?” and the second keynote speech entitled “The Challenge – Keeping

Figure 3. 2nd (and final) international conference of the Pri-Sci-Net project in Valetta (Malta)

IBSE active" was given by Prof. Lady Sue Dale Tunnicliffe (Institute of Education, University of London). An innovation of the conference was the opportunity provided to emerging researchers to present their work as keynote speakers. Also the delegates attended workshops in which they had the opportunity to participate (assuming the role of students) in inquiry-based activities, organized by partners involved in the project. Furthermore during the conference many teachers had the opportunity to present specific IBSE activities they designed and share their experiences with their implementation in the classroom.

In addition, the conference hosted a ceremony for awarding selected educators and young researchers with Certificates of Excellence. This was intended as a means of recognition of those teachers who are working to change the way that science is carried out in their classroom. This number of teachers will hopefully keep on growing with the aim to make it possible to really enhance actual teaching practice in science.

- *Four 20-hour national trainings on IBSE* for teachers and teacher-trainers in each of the 13 partner countries. All the partner countries will provide training to primary school teachers. When one counts the number of hours of training that have been provided by the project partnership this amounts to a minimum of 4 x 13 x 20, these amount to 1 040 hours of training to teachers all over Europe. Some of the partners have also provided more training than that promised and the overall feedback from teachers is that they continue to come back with requests for more training opportunities. Here below are some photos of training groups held.
- *Publication of the Journal 'Inquiry in Primary Science Education – IPSE'*: Another initiative of the project consortium was that of providing space for research on primary science and on inquiry in particular to find its way to publication. One of the project deliverables was the setting up and publication of the IPSE first edition of the Journal *'Inquiry in Primary Science'*. This journal provides space for science educators to publish as well as for teachers to provide inquiry notes where they can share their work and experience in implementing inquiry-based learning in science. The first edition of the journal includes a key paper by Wynne Harlen who is one of the main key actors in primary science at international level. The second edition will be published by the end of August 2014. The Journal can be currently accessed at the following address: www.prisci.net/IPSE

Conclusion

While the project is far from achieving an overall change in the pedagogy of doing science at primary level across Europe, it can be said that some seeds of change have been sown and that a number of teachers have demonstrated enthusiasm and commitment to doing science through inquiry. As the project is nearly at its end, the future of inquiry is now in the hands of those teachers who through their practice will act as the best possible ambassadors for inquiry-based learning in science and who are in the best position to convince other teachers to follow suit.

The project has taught the partners who are mainly science educators, how important it is that the activities promoted by the project need to allow space for teachers to adapt them to their context, to use their available resources and to different levels of children. The teachers have shared how they like to adapt the activities, like the story-telling perspective while keeping the investigation's characteristics close to the original version. Many teachers have shared how they observed a high level of interaction among young children when engaged in inquiry activities. It is the mental pictures of children's enthusiasm and excitement while inquiring that has kept and will keep the project partners working to promote the same vision for learning science even beyond the project!

Figure 4 and 5. Pri-Sci-Net training groups

References

Rocard, M., Csermely, P., Jorde, D., Lenzen, D. Walberg-Henriksson, H., & Hemme, V. (2007). *Science Education now: A renewed Pedagogy for the Future of Europe*, Brussels: European Commission.

Dejonckheere, P. J. N., Van De Keere, K., & Tallir, I. (2011). Are fourth and fifth grade children better scientists through metacognitive learning? *Electronic journal of research in educational psychology, 9(1) – Issue Online 23.*

Dejonckheere, P. J. N., Van de Keere, K., & Mestdagh, N. (2009). Training the scientific thinking circle in pre- and primary school children. *The Journal of Educational Research, 103, 1–16*.

Schraw, G., Crippen, K., & Hartley, K. (2006). Promoting Self-Regulation in Science Education: Metacognition as Part of a Broader Perspective on Learning. *Research in science education, 36*, 111–139.

Schraw, G., & Moshman, D. (1995). Metacognitieve theories. *Educational Psychology Review, 7*(4), 351–371.

Pri-Sci-Net has received funding from the European Union Seventh Framework Programme under grant agreement No.266647.

978-3-9816683-1-5