ECRICE 2016

European Conference on Research in Chemical Education

BARCELONA
7-10 September

BOOK OF ABSTRACTS

EuCheMS
European Chemical Sciences

CATALANA SOCIETAT QVÍMICA
INSTITVT D'ESTVDIS CATALANS

WELCOME

On behalf of the Catalan Chemical Society, we are pleased to invite you to Barcelona in September 2016 on the occasion of the 13th ECRICE conference.

The delegates of the Division of Education of EuCheMS of this society (SCQ) will lead this event in collaboration with the other delegates of EuCheMS Division of Education.

ECRICE is the forum for researchers and teachers to exchange research experiences in chemistry education and about teaching and learning chemistry at all levels. The conference has always attracted a significant number of participants from all over the world to discuss and to exchange idees on chemistry education. We hope that the current conference in Barcelona will be able to follow in the footsteps of the last highly interesting conferences in Jyväskylä (2014), Rome (2012), Cracow (2010).

The title of the 13th ECRICE in Barcelona is "Inspiring Science Education through Research" The main ideas behind the topic 2016 are:

Research achievements and conclusions should inspire innovative teaching methods to teach new generations with new challenges.

There is often a gap between chemistry education and research in chemistry. We need to improve and inspire chemistry education by taking into account research data in this field.

The results of research in teaching and education should be adapted to the needs of teachers, and should be transferred and disseminated effectively to the teaching community.

We look forward to seeing all our chemistry education friends in Barcelona.

With best regards,

Carles Bo
President of the Catalan Chemical Society and Cochair of the Conference

Fina Guitart
Delegate of the Catalan Chemical Society at the Division of Chemical Education of the EuCheMS and Cochair of the Conference

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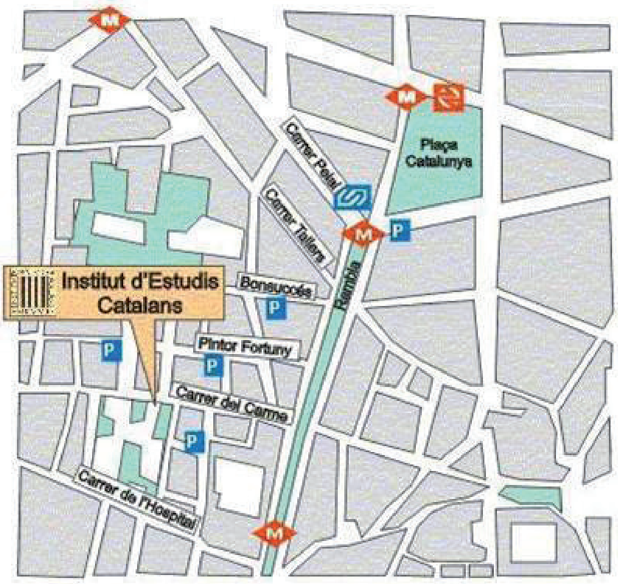
General Information

The **13th ECRICE** conference will be celebrated in Barcelona, 6-10th September 2016

Venue

Institut d' Estudis Catalans. C/ del Carme, 47. 08001 Barcelona

Institut d'Estudis Catalans (Institute for Catalan Studies, IEC), founded in 1907, is an academic institution whose main goals are high level scientific research and the promotion of knowledge. The Institut has affiliated societies which work in a wide variety of cultural, scientific and technological fields. One of the societies is the Catalan Chemistry Society.
The Casa de Convalescència de Sant Pau (Saint Paul's Convalescent Home), the historical and current headquarters of the IEC, is a magnificent XVII century civic building built for the convalescence of the sick at the neighboring Hospital de la Santa Creu (Hospital of the Holy Cross) (1401-1926). In the XVII century both buildings were on the outskirts of Barcelona.



Registration and general information
The secretariat and registration desk will be located at the hall of the Institut d' Estudis Catalans.
Open every day during the lectures times.

Registration fees
Regular fees include access to conference sessions and exhibition area, link to book of abstracts, welcome reception, lunches, coffee breaks and conference dinner.

One day ticket
The One day ticket includes access to conference sessions and exhibition area, lunches and coffee breaks during the day, as well as a link to book of abstracts. For any accepted communication as first author, a regular fee is required.
Only one day ticket is permitted per attendee. If you wish to attend more than one day, then the Regular participant fee will be required.

Student fee
Student fee registration is only available for students that are not professional teachers or researchers.
Regular participant fee is also required if they are the first author of any communication.
Accompanying person fee includes: welcome reception, lunches and coffee/tea during session breaks, conference dinner.
All fees exclude accommodation, which needs to be booked separately.
Conference Dinner (September, 9th, 2016) included except in the One day ticket fees .

Liability
ECRICE and the congress venue accept no liability for personal injuries sustained, loss or damage of property belonging to Conference participants, either or as a result of the Conference. Please check the validity of your own personal insurance before travelling.

Program
In the program, in voice communications, only it has a pedigree, the first author . For affiliations of the other authors must consult the abstract.

Conference Secretariat (Registration and abstracts collection)

pacific world
opening up perspectives

PACIFIC WORLD
World Trade Center
Moll de Barcelona, s/n
North Building, 8th floor
08039 Barcelona, Spain
ecrice2016@pacificworld.com

Welcome Reception

7th September 2016
20:45 h -23:15 h

http://www.museunacional.cat/en
http://www.museunacional.cat/en/getting-here

We will offer a delicious welcome cocktail and guided tours of the museum.

Optional Visits during the Welcome Reception

A) Medieval Romanesque Art

The collection of Romanesque art, 11th to 13th centuries, is made up of an exceptional set of mural paintings and a rich collection of panel paintings, the biggest and oldest in Europe. The outstanding metalwork is noteworthy, as well as the sculptures in wood and stone, in which it is worth highlighting the descent from the cross and the majesty pieces.

http://www.museunacional.cat/en/collections/medieval-romanesque-art

B) Historical visit to the Venue Building "Palau Nacional"

The Palau Nacional, constructed for the International Exposition of 1929, is the location of the Museu Nacional d'Art de Catalunya. The Palau Nacional, which just about extends to 50,000 m^2, is a building of major proportions, which relates to models of academic classicism of the period within the ambit of the universal exposition. Its façade is crowned by a large dome, inspired by that of St Peter's of the Vatican; two lesser domes on either side, and four towers inspired by the Cathedral of Santiago de Compostella.

It is located on the hill of Montjuïc, a privileged setting from which you can enjoy magnificent and unique views of Barcelona. The front access to the Palau Nacional is reached by a major stone staircase from the avenue of Reina Maria Cristina, flanked half way up by the major luminous and monumental fountains by Carles Buïgas.

http://www.museunacional.cat/en/unique-venues

Conference Dinner

1881 per SAGARDI is a traditional Mediterranean restaurant set up around a large outdoor terrace boasting a unique and privileged view of the Barcelona skyline.

Located in upper levels of the Museum of History of Catalonia, a building that was built following the English style found in ports around the world, where history and culture bring together countries and peoples. SAGARDI makes of this unique location a place of gastronomy, sensibility and emotions.

Conference Dinner
Friday, 9th September 2016
20:30 h

How to get there
1881 RESTAURANT (at the top floor of MUSEU D'HISTÒRIA DE CATALUNYA) "Palau de Mar"
Address: Pl. Pau Vila, 3
Zone: Barceloneta
District: Ciutat Vella
Code: 08003
How to get: BUS D20, 64,59,45, 39 Metro L4 Barceloneta

Optional guided visits to the Conference Venue Building “Institut d’ Estudis Catalans” (Conference Venue) 8th and 9th September 2016 12:30 h -13:05 h

There is the possibility of visiting the most interesting and private spaces of the Venue Bulding and of the Royal Academy of Medicine of Catalonia.

Option A) Historical presentation of the Building and visit to the most breathtaking places: baroque chapel and Mercè Rodoreda Gardens.

The Building is located in the former Convalescent Home in the heart of Raval, the Institute of Catalan Studies offers guided tours in order to let people know their space and the activities organized inside the Insitute.

Through a guided tour of 30-40 min will be visited the most interesting and unknown parts of the Building: the Baroque chapel and the garden Mercè Rodoreda among them. Explanations about his relevance will be provided.

http://www.bcncatfilmcommission.com/en/location/institut-destudis-catalans

Option B)) Royal Academy of Medicine of Catalonia

This Building is one of the most important pieces of neoclassical architecture in Barcelona. It must be appreciate primarily anatomical amphitheater of exceptional beauty. The architect Ventura Rodriguez was responsible.

http://www.ramc.cat/

Optional guided visits to the COSMOCAIXA Science Museum
10th September 2016

Carrer d'Isaac Newton, 26, 08022 Barcelona

The Science Museum Cosmocaixa is run by the social foundation "la Caixa" and constitutes an absolutely new concept of science museums. The museum is interactive, educational, and extremely attractive to the eye. The *Planetarium* invites you to take a journey through space and time, past the stars and planets of the firmament.

The museum building is just as fascinating as its contents. Cosmocaixa is a beautiful example of modernista architecture.

Guided tours to the museum exhibitions or the Planetarium.

https://obrasociallacaixa.org/en/ciencia/cosmocaixa/el-museo
https://obrasociallacaixa.org/en/

ECRICE 2016
European Conference on Research in Chemical Education
BARCELONA 7-10 September

Tuesday 6th September
Pre-Registration // Welcome to ECRICE 2016
19:00 – 21:00 Venue Bulding (Cloister – Ground Floor)
Snacks and Refreshments
Musical Welcome (20:00 - 20:30)

	Wednesday 7th September			Thursday 8th September			Friday 9th September			Saturday 10th September		
	Room 1	Room 2	Room 3	Room 1	Room 2	Room 3	Room 1	Room 2	Room 3	Room 1	Room 2	Room 3
8:30 9:40	8:30 - 8:55 OPENNING CEREMONY			8:30 - 9:25 Plenary Lecture PL02 Rachel Mamlok-Naaman and Ron Blonder			8:30 - 9:25 Plenary Lecture PL03 Ilka Parchmann			8:45 - 9:40 Plenary Lecture PL04 Odilla Finlayson		
9:00 10:15	9:00 - 9:55 Plenary Lecture PL01 Ton de Jong			9:30 - 10:15 Keynote Lecture KN05 Ingo Eilks	9:30 - 10:15 Keynote Lecture KN06 Norb Pienta		9:30 - 10:15 Keynote Lecture KN08 Marcy Towns	9:30 - 10:15 Keynote Lecture KN09 Maija Aksela		9:45 - 11:00 Symposium (OC 8.1) S14 - S17	9:45 - 11:00 Oral Communications OC 8.2 OC83 - OC87	9:45 - 11:00 Oral Communications OC 8.3 OC88 - OC92
10:00 11:00	10:00 - 10:45 Keynote Lecture KN01 Diane M. Bunce	10:00 - 10:45 Keynote Lecture KN02 Sarah Hayes		10:15 - 10:45 Coffee Break (Cloister - Ground Floor)			10:15 - 10:45 Coffee Break (Cloister - Ground Floor)					
10:50 11:35	10:50 - 11:20 Coffee Break (Cloister - Ground Floor)			10:50 - 11:35 Keynote Lecture KN07 Cecília Galvão	10:50 -11:35 Chemical Demonstration CD03 Klemens Koch		10:50 - 11:35 (Cloister 1rst Floor) Poster Communications PC2 (P31- P55) Presentation by the authors (P31- P43)			11:00 - 11:30 Coffee Break (Cloister - Ground Floor)		
11:25 12:25	11:25 - 12:10 (Cloister 1rst Floor) Poster Communications PC1 (P01- P30) Presentation by the authors (P01- P15)			11:40 - 12:25 Oral Communications OC 3.1 OC22 - OC24	11:40 -12:25 Oral Communications OC 3.2 OC25 - OC27	11:40 - 12:25 Oral Communications OC 3.3 OC28 - OC30	11:40 - 12:25 Keynote Lecture KN10 Martin Bílek	11:40 - 12:25 Chemical Demonstration CD04 Robert Worley		BUS DEPARTURE FOR COSMOCAIXA Science Museum (estimated arrival 12:15)		
12:15 13:25	12:15 - 13:00 Keynote Lecture KN03 Murat Kahveci	12:15 - 13:00 Chemical Demonstration CD01 David Katz		12:30 - 13:05 Guided tour of the Venue Building or Academy of Medicine (Optional)			12:30 - 13:05 Guided tour of the Venue Building or Academy of Medicine (Optional)			12:30 - 13:25 (Sala Àgora COSMOCAIXA) Plenary Lecture PL05 Melanie M Cooper		
13:10 14:10	13:10 - 14:10 Lunch (Cloister - Ground Floor)			13:10 - 14:10 Lunch (Cloister - Ground Floor)			13:10 - 14:10 Lunch (Cloister - Ground Floor)			13:25 - 14:00 (Sala Àgora COSMOCAIXA) CLOSING CEREMONY		
14:15 15:45	14:15 -15:30 Symposium (OC 1.1) S01 - S04	14:15 -15:30 Oral Communications OC 1.2 OC01 - OC05	14:15 -15:30 Oral Communications OC 1.3 OC06 - OC09	14:15 -15:30 Symposium (OC 4.1) S05- S08	14:15 -15:30 Oral Communications OC 4.2 OC31- OC35	14:15 -15:30 Oral Communications OC 4.3 OC36- OC40	14:15 -15:45 Symposium (OC 6.1) S09 - S013	14:15 -15:45 Oral Communications OC 6.2 OC56- OC61	14:15 -15:45 Oral Communications OC 6.3 OC62- OC67	14:00 - 14:30 (COSMOCAIXA) FAREWELL APPETIZER		
15:30 16:50	15:35: - 16:20 (Cloister 1rst Floor) Poster Communications PC1 (P01- P30) Presentation by the authors (P16 - P30)			15:35 -16:50 Oral Communications OC 5.1 OC41- OC45	15:35 -16:50 Oral Communications OC 5.2 OC46- OC50	15:35 -16:50 Oral Communications OC 5.3 OC51- OC55	15:50: - 16:35 (Cloister 1rst Floor) Poster Communications PC2 (P31- P58) Presentation by the authors (P44- P58)			15:30 - 16:30 Guided tours to COSMOCAIXA Science Museum or Planetarium (Optional)		
16:25 17:25	16:25 -16:55 Coffee Break (Cloister - Ground Floor)			16:55 - 17:25 Coffee Break (Cloister - Ground Floor)			16:40 - 17:10 Coffee Break (Cloister - Ground Floor)					
17:00 17:55	17:00 - 17:45 Keynote Lecture KN04 Astrid Bulte	17:00 - 17:45 Chemical Demonstration CD02 Josep Duran		17:30 -18:15 WS 01 Workshop Optional Norbert Pienta Ingo Eilks			17:10 - 17:55 Keynote Lecture KN11 Dragica Trivic	17:10 - 17:55 Chemical Demonstration CD05 Carles Lozano				
17:50 19:15	17:50 - 18:50 Oral Communications OC 2.1 OC10 -OC13	17:50 - 18:50 Oral Communications OC 2.2 OC14 - OC17	17:50 - 18:50 Oral Communications OC 2.3 OC18 - OC21				18:00 - 19:15 Oral Communications OC 7.1 OC68 - OC72	18:00 - 19:15 Oral Communications OC 7.2 OC73 - OC77	18:00 - 19:15 Oral Communications OC 7.3 OC78 - OC82			
20:45 23:15	20:45 - 23:15 WELCOME RECEPTION Museu Nacional d'Art de Catalunya (MNAC)						20:45 - 23:15 CONFERENCE DINNER Restaurant Museu Història de Catalunya					

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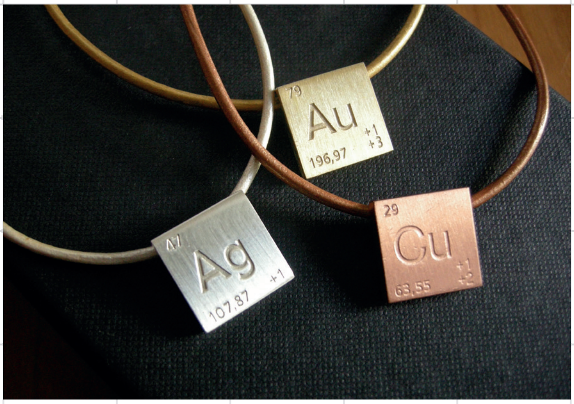
BARCELONA



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Tuesday 6th September

Cloister (Ground floor)

19:00 – 21:00 **Pre-Registration //Welcome to ECRICE2016**
Snacks and Refreshments–Musical Welcome (20:00-20:30 h)

Wednesday 7th September

Room 1 Sala Prat de la Riba / Room 2 Sala Pere i Joan Coromines

8:30–8:55 **OPENING CEREMONY:**
13th ECRICE Inspiring Chemistry Education Through Research

Room 1 Sala Prat de la Riba

9:00–9:55 **Plenary Lecture:**
PL 01 Online labs in science education, new possibilities for active student learning
Ton de Jong, *University of Twente*, The Netherlands

Room 1 Sala Prat de la Riba

10:00 – 10:45 **Keynote Lecture:**
KN 01 A new approach to Pedagogical Change: Research the Problem and Involve the Teachers in the Process
Diane M. Bunce, *The Catholic University of America*, Washington, DC, United States

Room 2 Sala Pere i Joan Coromines

10:00 – 10:45 **Keynote Lecture:**
KN 02 Informal Chemistry Education: A Missed Opportunity?
Sarah Hayes, *University of Limerick*, Ireland

10:50 – 11:20 **Coffee Break – Cloister (Ground floor)**

Poster Communications PC1 (Cloister – 1st Floor)

11:25 – 12:10 **Poster Communications PC1 (P 1-P 30) (see the lists at the end of program)**
List of PC1.1: Presentation by the authors (P 1-P 15)

Room 1 Sala Prat de la Riba

12:15 – 13:00 **Keynote Lecture:**
KN 03 Advancing Chemistry Education Research: Dual-Process Theories, Learning Objects and Student Response Systems
Murat Kahveci, *Canakkale Onsekiz Mart University*, Turkey

Room 2 Sala Pere i Joan Coromines

12:15 – 13:00 **Chemical Demonstration**

CD 01 Nanotechnology experiments for general chemistry laboratory classes
David Katz, *Pima Community College,* Arizona, United States

13:10 – 14:10 **Lunch (Ground floor)**

Room 1 Sala Prat de la Riba

14:15 – 15:30 **OC 1.1 Symposium: Towards more relevant Chemistry Education**
Chairs: Ingo Eilks, *University of Bremen,* Germany and Avi Hofstein, *The Weizmann Institute of Science,* Israel

S 01 Towards Eco-Reflexive And Transformative Learning In Chemistry Education
Jesper Sjöström, *Malmö University,* Sweden

S 02 Medicines In My Life: An Authentic Contextualised Module For Pupils And Teachers
Sarah M. Hayes, *University of Limerick,* Ireland

S 03 From Students' Chemistry Interest In Internet Forums To Classroom Practice
Johanna Dittmar and Ingo Eilks, *University of Bremen,* Germany

S 04 Directions And Obstacles Regarding Research, Development, and Practice for Relevant Chemistry Education
Avi Hofstein, *The Weizmann Institute of Science* and Ingo Eilks, *University of Bremen,* Israel and Germany

Room 2 Sala Pere i Joan Coromines

14:15 – 15:30 **OC 1.2 Oral Communications (OC 01-OC 05)**
Chair: Lemonia Antonoglou, *Aristotele University of Thessaloniki,* Greece

OC 01 Investigating And Mitigating Chemistry Students' Illusions Of Competence
Pazicni, Sam, *University Of New Hampshire ,* United States

OC 02 Using Reflections To Promote Metacognitive Awareness In Students' Conceptual Understanding And Problem Solving Abilities In Chemistry
Dianovsky, Michael, *South Dakota State University,* United States

OC 03 Feedback In Blended Learning Laboratory Classes As A Way To Improve Success Of Student Teachers
Hedtrich, Sebastian Graulich, Nicole, *Justus-Liebig-University,* Germany

OC 04 Theater In Chemistry Education: Analysis Of An Experience At The University Of Valencia
Pou Amérigo, Rosendo; Climent, Teresa; García Lopera, Rosa; Piñana, Estefania; Colorado, Inmaculada; *University Of Valencia,* Spain

OC 05 The Investigation Of Pre-Service Elementary Science Teachers' Interest In Acid-Base
Çiçek, Ozge; Ilhan, Nail; *Kilis 7 Aralik University*, Turkey

Room 3 Sala Pere i Joan Coromines

14:15 – 15:30 **OC 1.3 Oral Communications (OC 06 - OC 09)**
Chair: Pere Grapi, *Societat Catalana d'Història de la Ciència i de la Tècnica*, IEC, Spain

OC 06 Progress In Primary School Children's Understandings Of Dissolving: A Cross-Age Qualitative Survey
Tsapali, Maria; Quinn, Connor; Ellefson, Michelle R.; Schlottmann, Anne; Taber, Keith S., *University of Cambridge,* United Kingdom

OC 07 The Quest To Design Effective Visualizations
Kelly, Resa, *San José State University,* United States

OC 08 Graphical Representations In Electrochemistry–Do They Relieve Some Difficulties?
Eriksson, Lars; Kaufmann, Ilana, *Stockholm University,* Sweden

OC 09 Finnish Subject Teachers' Perceptions Of Art Integration In Chemistry Education
Turkka, Jaakko; Aksela, Maija, *University of Helsinki,* Finland

Poster Communications PC1 (Cloister – 1st Floor)

15:35 – 16:20 **Poster Communications PC1 (P 1 - P 30) (see the lists at the end of program)**
List of PC1.2: Presentation by the authors (P 16 - P 30)

16:25 – 16:55 **Coffee Break – Cloister (Ground floor)**

Room 1 Sala Prat de la Riba

17:00 – 17:45 **Keynote Lecture:**

KN 04 An Instructional Framework for Transforming Authentic Practices into Contexts for the outline of Chemistry Curricula
Astrid Bulte, *University of Utrecht,* Germany

Room 2 Sala Pere i Joan Coromines

17:00 – 17:45 **Chemical Demonstration:**

CD 02 From alchemists to catalysts through experiments you can do in the classroom
Josep Duran, *University of Girona*, Spain

Room 1 Sala Prat de la Riba

17:50 – 18:50 **OC 2.1 Oral Communications (OC 10 - OC 13)**
Chair: Klemens Koch, *Pedagogical University Berne,* Switzerland

OC 10 The Investigation Of Pre-Service Teachers' Self-Efficacy Perceptions On Acid-Base Topic
Ozge Çiçek,, Nail Ilhan, *Kilis 7 Aralık University*

OC 11 Measuring Aspects Of Students¿ Motivation Towards Learning Chemistry
Skorsepa, Marek; Kmetova, Jarmila, *Matej Bel University,* Slovakia

OC 12 "On-Line Continous Assessment"-What Do Students Think?
O' Malley, Pat; Finlayson, Odilla, *Dublin City University,* Ireland

OC13 The Magic Of The Periodic Table: From Illusion To Game
Duran Carpintero, Josep; Vieta, Pep Anton; Duran, Miquel; Blasco, Fernando; Guillaumes, Laia; Simon, Silvia*, Universitat de Girona,* Spain

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Room 2 Sala Pere i Joan Coromines

17:50 – 18:50 **OC 2.2 Oral Communications (OC 14 - OC 17)**
Chair: Karolina Broman, Umea University, Sweden

OC 14 Activity-Based Chemistry Teaching Materials at Compulsory Secondary School: results of classroom implementation
Izquierdo Aymerich, Merce; Aliberas, Joan; Guitart Mas, Fina, *Universitat Autònoma de Barcelona,* Spain

OC 15 Investigating and Evaluating Outreach and Public Engagement Programmes, to establish whether they can Improve/Enhance Scientific Literacy
Hayes, Sarah; Ryan, Laurie; Childs, Peter; Croker, Denise, *University of Limerick,* Ireland

OC 16 Longitudinal Study Of Students' Conceptual Structures Concerning Chemical Bonding From Middle School To Upper Secondary School
Joki, Jarkko; Aksela, Maija, *University of Helsinki,* Finland

OC 17 Chemical Names And Formulas: French Students' difficulties
Kermen, Isabelle; Canac, Sophie, *University of Paris-Est Créteil,* France

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Room 3 Sala Nicolau d'Olwer

17:50 – 18:50 **OC 2.3 Oral Communications (OC 18 - OC 21)**
Chair: Jan Reguli, *Trnava University,* Slovakia

OC 18 Effect of course redesign on student learning in an introductory chemistry course
Raje, Sonali, *Towson University,* United States

OC 19 Analysis of how chemical knowledge is transferred in context-based education: students' difficulties and ways of reasoning
Marchan, Ivan; Sanmarti, Neus, *Universitat Autònoma de Barcelona,* Spain

OC 20 Parents and students cooperatively experiencing chemistry
Silvija, Markic, *University of Bremen,* Germany

OC 21 Adapting Participatory Action Research for Developing Chemistry Student Teachers' Diagnostic Knowledge
Tolsdorf, Yannik; Silvija, Markic *University of Bremen,* Germany

20:45 – 23:15 **WELCOME CEREMONY–MUSEU NACIONAL D'ART DE CATALUNYA (MNAC)**

Thursday 8th September

Room 1 Sala Prat de la Riba / Room 2 Sala Pere i Joan Coromines

8:30 – 09:25 **Plenary Lecture:**

PL 02 Learning science through contemporary research vs. using a historical approach
Rachel Mamlok-Naaman, and Ron Blonder, *The Weizmann Institute of Science,* Israel

Room 1 Sala Prat de la Riba

9:30 – 10:15 **Keynote Lecture:**

KN 05 How to transform the learning of chemistry into relevant education
Ingo Eilks, *University of Bremen,* Germany

Room 2 Sala Pere i Joan Coromines

9:30 – 10:15 **Keynote Lecture:**

KN 06 Studying Student Behavior and Chemistry Skills Using Browser-based Tools
Norbert Pienta, *University of Georgia,* United States

10:15 – 10:45 **Coffee Break – Cloister (Ground floor)**

Room 1 Sala Prat de la Riba

10:50 – 11:35 **Keynote Lecture:**

KN 07 Inquiry based learning: some results of research in Chemistry education in Portugal
Cecília Galvão, *University of Lisbon,* Portugal

Room 2 Sala Pere i Joan Coromines

Chemical Demonstration:

CD 03 Inquiring energy through simple experiments: a differentiation of concepts to strengthen energy literacy
Klemens Kock, *Pedagogical University of Berne,* Switzerland

11:40 – 12:25 **OC 3.1 Oral Communications (OC 22 - OC24)**
Chair: Hana Ctrnactova, *Charles University,* Czech R.

OC 22 Small Children's Non-Formal Chemistry Education Virtually At Homes' Parent'S Needs For Support
Vartiainen, Jenni; Aksela, Maija, *University of Helsinki,* Finland

OC 23 Multimedia in Chemistry teaching in Portugal: a review of recent research
Paiva, João Carlos; Morais, Carla; Moreira, Luciano, *Universidade do Porto,* Portugal

	OC 24 A Design-Based Research: Student-Centered Chemistry Education Through The Use Of Students` Questions Herranen, Jaana; Aksela, Maija, *University of Helsinki,* Finland
11:40 – 12:25	**OC 3.2 Oral Communications (OC 25 - OC 27)** **Chair:** Miia Rannikmae, University of Tartu, Estonia
	OC 25 ***Chemistry In Context*****: A Curricular Project For High School Education. Strengths And Weaknesses From Teachers' And Students' Feedback** Guitart Mas, Fina; Corominas Viñas, Josep, *CESIRE. Education Department. Catalonia's Government,* Spain
	OC 26 Context And Topic –Which Aspects Of Context-Based Chemistry Problems Do Upper Secondary Students Perceive Most Relevant And Interesting? Broman, Karolina; Bernholt, Sascha; Parchmann, Ilka, *Umeå University,* Sweden
	OC 27 Using Active Learning In The Classroom: Teacher And Student Experiences Teuling, Eva; Apotheker, Jan, *Rijksuniversiteit Groningen,* The Netherlands

Room 3 Sala Nicolau d'Olwer

11:40 – 12:25	**OC 3.3 Oral Communications (OC 28 - OC 30)** **Chair:** Mariann Holmberg, *Arcada University Of Applied Sciences,* Finland
	OC 28 Food Science Students' Understanding Of Chemical Kinetics Habiddin, Habiddin; Page, Elizabeth, *University of Reading,* United Kingdom
	OC 29 Investigations For Pre-Service Chemistry Teachers Maciejowska, Iwona; Finlayson, Odilla, *Jagiellonian University,* Poland
	OC 30 Foundation Year Medical Student Perspectives Of An Inquiry Based Chemistry Programme–Pogil (Process Oriented Guided Inquiry Learning) Gaynor, Declan, *Royal College of Surgeons in Ireland Medical University of Bahrain,* Bahrain
12:30 – 13:05	**Optional Guided tour of the Venue Building or Academy of Medicine** *(Optional, see for inscription in Social Events)*
13:10 – 14:10	**Lunch (Ground floor)**

Room 1 Sala Prat de la Riba

14:15 – 15:30	**OC 4.1 Symposium:** Teacher Training made irresistible **Chair:** Sevil Akaygun, *Bogazici University,* Turkey
	S 05 Understanding Responsible Research And Innovation: Perspective Of Teachers Jesper Sjöström / Sevil Akaygunand Emine, *Malmö University / Adadan, Bogazici University,* Sweden / Turkey
	S 06 Science Teachers' Training In Implementing Cutting-Edge Research Topics In Science Classes Katerina Salta, Emily Michailidi And Dimitris Stavrou. *University Of Crete,* Greece
	S 07 The Use Of A Community Of Learners As A Professionalization Tool Iwona Maciejowska, Malgorzata Kzeckowska. *Jagiellonian University,* Krakow

S 08 Teachers' Concern Profiles In Teaching Responsible Research And Innovation
Miikka De Vocht, Antti Laherto, And Ilka Parchamann, *University Of Helsinki / University Of Kiel,* Finland / Germany

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Room 2 Sala Pere i Joan Coromines

14:15 – 15:30 **OC 4.2 Oral Communications (OC 31 - OC 35)**
Chair: Mustafa Sozbilir, *Atatürk University,* Turkey

OC 31 Labdog: A Novel Web-Technology To Enhance Learning In The Lab
Wilson, Thomas; Read, David, *University of Southampton,* United Kingdom

OC 32 "Creating Creativity": Improving Pre-Service Teachers' Conceptions About Creativity In Chemistry
Reiners Christiane S., Bliersbach, Markus, *University of Cologne,* Germany

OC 33 Biology And Chemistry Preservice Teachers¿ Opinions Towards The Nature Of Science (NOS)
Gul, Seyda; Ozay Kose, Esra; Sozblir, Mustafa, *Ataturk University,* Turkey

OC 34 A Study Of The Perception Of Chemistry In Young Generations And Of Their Chemical/Scientific Knowledge In Italy
Domenici, Valentina; Chiocca, Giulia, *Università di Pisa,* Italy

OC 35 What Is Chemistry Today? Analyzing The Image Of Chemistry From Twitter Messages
Cuadros, Jordi; Guerris Larruy, Manuel; González-Sabaté, Lucinio, *IQS-Universitat Ramon Llull,* Spain

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Room 3 Sala Nicolau d'Olwer

14:15 – 15:30 **OC 4.3 Oral Communications (OC 36 - OC 40)**
Chair: Peter Childs, *University of Limerick,* Ireland

OC 36 How Do Students' Interest And Conceptual Understanding Develop Over The Time Of Their Secondary Chemistry Education? First Results From The Binational Project DolLIS
Bernholt, Sascha; Blankenburg, Janet; Broman, Karolina; Parchmann, Ilka, *Kiel University,* Germany

OC 37 Promoting Understanding Over Rote Learning: Self-Assessment In Mechanistic Organic Chemistry
Barnes, Stephen; Read, David, *University of Southampton,* United Kingdom

OC 38 Application Of Three-Tier Test To Assess Students' Misconceptions About Lipids
Milenkovic, Dusika; Hrin, Tamara; Segedinac, Mirjana; Horvat, Saša, *University of Novi Sad,* Serbia

OC 39 Designing Scaffolds To Teach Chemical Bonding Through Laboratory Inquiry
Crujeiras-Pérez, Beatriz, *University of Santiago de Compostela,* Spain

OC 40 Characterizing The Link Between Chemical Identity Thinking And Biochemical Contexts
Ngai, Courtney; Sevian, Hannah, *University of Massachusetts Boston,* United States

Room 1 Sala Prat de la Riba

15:35 – 16:50 **OC 5.1 Oral Communications (OC 41- OC45)**
Chair: Iwona Maciejowska, *Jagiellonian University,* Poland

OC 41 Primary School Students In Chemistry Laboratory: Inquiry, Learning And Experience In Authentic Environment
Häkkinen, Pirjo; Lundell, Jan, *University of Jyväskylä,* Finland

OC 42 Chemistry Lab-Centered Activities For 6-10 Years Old Children At The Science Museum
Domenici, Valentina; Gerardi, Chiara; Parri, Erica; Lenzi, Alessandro, *Università di Pisa,* Italy

OC 43 Engaging Pre-Service Primary Teachers In Scientific Practices: Planning An Investigation And Communicating Results
Crujeiras Pérez, Beatriz, *Universidade de Santiago de Compostela,* Spain

OC 44 Chemistry by inquiry for initial teacher education
Finlayson, Odilla; Hinch, Leeanne; McLoughlin, Eilish; Van Kampen, Paul, *CASTEL, Dublin City University,* Ireland

OC 45 How French Students Use The Language Of Chemistry
Kermen, Isabelle; Canac, Sophie, *University of Paris-Est Créteil,* France

Room 2 Sala Pere i Joan Coromines

15:35 – 16:50 **OC 5.2 Oral Communications (OC 46 - OC 50)**
Chair: Josep Duran, *University of Girona,* Spain

OC 46 What Makes A Successful Chemistry School?
Childs, Peter; Waldron, Lisa; McCarthy, Megan, *University of Limerick,* Ireland

OC 47 Secondary School Students' Perceptions Of Working Life Skills In Science-Related Careers
Keinonen, Tuula; Hartikainen Ahia, Anu; Salonen, Anssi, *University of Eastern Finland,* Finland

OC 48 Evaluating Scenarios Which Promote Student's Science Related Career Awareness–An Estonian Experience In Multico Project.
Rannikmäe, Miia; Holbrook, Jack; Soobard, Regina; Kotkas, Tormi, *University of Tartu,* Estonia

OC 49 3D Printing For Chemistry. How We Do It?
Śmejkal, Petr; Šmejkal, Petr; Míka, Ludìk; Ètrnáctová, Hana; Martínek, Václav, *Charles University in Prague,* Czech Republic

OC 50 Triadic Dialog Interactions In Chemistry Learning Facebook Group
Blonder, Ron*;* Rap, Shelley, *Weizmann Institute of Science,* Israel

Room 3 Sala Nicolau d'Olwer

15:35 – 16:50 **OC 5.3 Oral Communications (OC 51 - OC 55)**
Chair: May Britt Stjerna, *Norwegian Chemical Society,* Norway

OC 51 Drama For Inclusion In Science: Recognising The Role Of Artisan Input.
Oversby, John, *University of Reading,* Wales

OC 52 Sneaking The History Of Science Through Its Images In Science Teacher Education. The Case Of The Pneumatic Trough
Pere Grapí, *Universitat Autònoma de Barcelona,* Spain

OC 53 History Of Chemistry And Nature Of Science: What Do These Mean To Chemistry Teachers
Milanovic, Vesna; Trivic, Dragica, *University of Belgrade,* Serbia

OC 54 Towards Relevant Integrated Chemistry Education
Haatainen, Outi; Maija Aksela, *University of Helsinki,* Finland

OC 55 Students' Understanding Of Heat And Temperature: A Cross-Age Study
Yavuzkaya, Merve Nur; Adadan, Emine, *Bogazici University,* Turkey

16:55 – 17:25 **Coffee Break – Cloister (Ground floor)**

Room 1 Sala Prat de la Riba

17:30 – 18:15 WS 1 **(OPTIONAL)**

Quality publishing in chemical educations journals
Norbert Pienta and Ingo Eilks, *University of Georgia, University of Bremen,* United States and Germany

Friday 9th September

Room 1 Sala Prat de la Riba / Room 2 Sala Pere i Joan Coromines

8:30 – 09:25 **Plenary Lecture:**

PL 03 How to engage students in and for science? Perspectives for school and out-of-school learning
Ilka Parchmann**,** *Kiel University,* Germany

Room 1 Sala Prat de la Riba

9:30 – 10:15 **Keynote Lecture:**

KN 08 Undergraduate Chemistry Laboratory: Goals and Novel Assessments
Marcy Towns, *Purdue University,* Indiana, United States

Room 2 Sala Pere i Joan Coromines

9:30 – 10:15 **Keynote Lecture:**

KN 09 Promoting holistic sustainable development through chemistry teacher education
Maija Aksela, *University of Helsinki,* Finland

10:15 – 10:45 **Coffee Break – Cloister (Ground floor)**

Cloister – 1st Floor

10:50 – 11:35 **Poster Communications PC 2 (P31-P58) (see the lists at the end of program)**
List of PC2.1: Presentation by the authors (P31-P43)

Room 1 Sala Prat de la Riba

11:40 – 12:25 **Keynote Lecture:**

KN 10 Virtual and Real Environments Interaction in Chemistry Education
Martin Bílek, *University of Hradec Králové,* Czech Republic

Room 2 Sala Pere i Joan Coromines

11:40 – 12:25 **Chemical Demonstration:**

CD 04 "In a little you can see a lot": The impact of practical microscale chemistry on chemical education
Robert Worley, B*runel University Science Park,* United Kingdom

12:30 – 13:05 **Optional Guided tour of the Venue Building or Academy of Medicine**
(Optional, see for inscription in Social Events)

13:10 - 14:10 **Lunch (Ground floor)**

Room 1 Sala Prat de la Riba

14:15 – 15:45 **OC 6.1 Symposium: The IRRESISTIBLE way to engage school students with RRI**
Chair: Jan Apotheker, *University Of Groningen,* The Netherlands

S 9 The Project Irresistible: Introducing Responsible Research and Innovation into the Secondary School Classroom
Jan Apotheker, *University Of Groningen,* The Netherlands

S 10 The Rationale Of Responsible Research And Innovation (Rri) In Science Education.
Ron Blonder, Shelley And Sherman Rosenfeld, *Weizmann Institute Of Science,* Israel

S 11 Irresistible Exhibitions On Responsible Research And Innovation: The Impact Of The Process Of Exhibition Development On Both Students And Teachers.
Rita Marques, Patrícia Azinhaga, Pedro Reis, Elisabete Linhares And Mónica Baptista, *Lisbon University,* Portugal

S 12 Exploring Students' Motivation While Creating A Student Curated Exhibition
Lorenz Kampschulte, Daniela Ingwersen, And Ilka Parchmann. *Leibniz Institute For Science And Mathematics Education,* Germany

S 13 Exploring Students' Attitudes Toward Responsible Research And Innovation In The Context Of Nanotechnology Applications Module.
Emine Adadan, Sevil Akaygun, *Bogazici University,* Turkey

Room 2 Sala Pere i Joan Coromines

14:15 – 15:45 **OC 6.2 Oral Communications (OC 56 - OC 61)**
Chair: Rachel Mamlok-Naaman, *The Weismann Institute,* Israel

OC 56 The Tip Of The Iceberg In Organic Chemistry Classes
Graulich, Nicole, *Justus-Liebig Universität Gießen,* Germany

OC 57 Organic Light Emitting Diodes -Implementing An Innovative Technology Into Chemistry Classes
Banerji, Amitabh; Dörschelln, Jennifer, *University of Cologne,* Germany

OC 58 A Comparative Study On Presentation Of Le Châtelier's Principle (LCP) In High School Chemistry Textbooks In Spain And Turkey
Quílez, Juan; Canpolat, Nurtac; Sözbilir, Mustafa; Pinarbasi, Tacettin, *Universitat Jaume I. Castelló de la Plana*, Spain

OC 59 Conceptual And Inclusive Chemistry Learning–A Contradiction
Abels, Simone, *Leuphana University Lüneburg,* Germany

OC 60 Pre-Service Primary School Teachers' Understanding Of Chemical Bond At The Submicroscopic Level
Devetak, Iztok; Slapnièar, Miha, *University of Ljubljana,* Slovenia

OC 61 Is Avogadro Number An Irrational Number?
Libran, Antoni; Izquierdo, Mercè, *Universitat Autònoma de Barcelona,* Spain

Room 3 Sala Nicolau d'Olwer

14:15 – 15:45 **OC 6.3 Oral Communications (OC 62 - OC 67)**
Chair: Ilka Parchmann, *Kiel University,* Germany

OC 62 Chemistry Teachers' Views Of ChemistryLab Gadolin As A Meaningful Nonformal Learning Environment
Ikävalko, Veli-Matti; Aksela, Maija, *University of Helsinki,* Finland

OC 63 Fostering Positive Attitudes Towards Science And Chemistry: What Needs To Change In The Classroom?
Duckmanton, Paul; Koramoah, Rachel; Read, David, *University of Southampton,* United Kingdom

OC 64 Evidences Of The Relationship Between Recreational Chemistry And The Increase Of Chemical Vocations
Duran Carpintero, Josep; Vieta Corcoy, Pep Anton; Duran Portas, Miquel, *Universitat de Girona,* Spain

OC 65 The Role Of Non-Formal Chemistry Learning Environments For Curriculum Design And Innovation
Affeldt, Fiona; Antje Siol; Silvija Markic; Ingo Eilk, *University of Bremen,* Germany

OC 66 Understanding The Differences In The Chemistry Learning Environments In New Zealand High Schools And Universities
Boniface, Suzanne, *Victoria University of Wellington,* New Zealand

OC 67 Interactive Whiteboards For Teaching Chemistry And Resulting Tensions Of Their Use
Grimalt-Álvaro, Carme; Ametller, Jaume; Pintó, Roser, *CRECIM,* Spain

Poster Communications PC2 (Cloister – 1st Floor)

15:50 – 16:35 **Poster Communications PC 2 (P 31 - P 58) (see the lists at the end of program)**
List of PC2.2: Presentation by the authors (P 44 - P 58)

16:40 – 17:10 **Coffee Break – Cloister (Ground floor)**

Room 1 Sala Prat de la Riba

17:10 – 17:55 **Keynote Lecture:**

KN 11 The development of pre-service chemistry teachers' pedagogical content knowledge through research activities
Dragica Trivic, *University of Belgrade,* Serbia

Room 2 Sala Pere i Joan Coromines

17:10 – 17:55 **Chemical Demonstration:**

CD 05 APQUA Project: 25 years of integrated inquiry-based, issue-oriented and hands-on science education in grades 4-11
Carles Lozano, *University Rovira i Virgili,* Spain

Room 1 Sala Prat de la Riba

18:00 – 19:15 **OC 7.1 Oral Communications (OC 68 - OC 72)**
Chair: Jordi Cuadros, *IQS Univ. Ramon Llull*

OC 68 Learning Higher-Order Thinking Skills In General Chemistry: Using The "ChemEd X Data" Website To Teach Students Self-Regulation
Prat-Resina, Xavier, *University of Minnesota Rochester,* United States

OC 69 Mapping Students' Understanding Ashok Of Hydrogen Bonding
Akaygun, Sevil; Lundell, Jan, *Bogazici University*, Turkey

OC 70 Tailoring E-Learning Environment For Chemistry Education
Ahokas, Jussi; Koliseva, Anniina; Pyykkö, Lassi; Lundell, Jan, *University of Jyväskylä,* Finland

OC 71 Informing Teaching Practices By Investigating Undergraduate Chemistry Students- Online Homework Usage
Gulacar, Ozcan; Bowman, Charles, *University of California-Davis,* United States

OC 72 Science Teachers' Experiences About Guiding Students Along The Development Of An Interactive Science Exhibition Artifacts.
Açikel, Büsra; Akaygun, Sevil; Adadan, Emine, *Bogazici University,* Turkey

Room 2 Sala Pere i Joan Coromines

18:00 – 19:15 **OC 7.2 Oral Communications (OC 73 - OC 77)**
Chair: Jan Apotheker, *University Of Groningen,* The Netherlands

OC 73 Experimenting With Ice: Suggestions For Active Inquiry-Based Learning Of Science And STEM Competences
Pinto, Gabriel; Lahuerta, Pascual; Martín Sánchez, Manuela; Martín Sánchez, María Teresa, *Universidad Politécnica de Madrid,* Spain

OC 74 Possibilities For Chemistry Education Provided By Scientix And STEM Alliance
Mihai, Gina; Debry, Maïté Gras-Velázquez, Àgueda, *European Schoolnet,* Belgium

OC 75 Inquiry-Based Learning As A Predictor Of Adolescents' Science-Related Career Aspiration
Kang, Jingoo; Keinonen, Tuula, *University of Eastern Finland,* Finland

OC 76 Chemistry Teachers' Training As The Most Important Condition For IBSE Teaching
Čtrnáctová, Hana; Teplá, Milada; Čtrnáctová, Lenka; Stratilová Urválková, Eva; Šmejkal, Petr, *Charles University in Prague,* Czech Republic

OC 77 Education Through Science As An Approach To Make Chemistry Education Relevant In The Eyes Of Students
Rannikmäwe, Miia; Holbrook, Jack, *University of Tartu,* Estonia

Room 3 Sala Nicolau d'Olwer

18:00 – 19:15 **OC 7.3 Oral Communications (OC 78 - OC 82)**
Chair: Odilla Finlayson, *Dublin City University,* Ireland

OC 78 Teachers' Misconceptions About Reaction Rate And Acid-Base Chemistry
Cheung, Derek *The Chinese University of Hong Kong,* China

OC 79 (Re)Construction Of Students' Conceptions About Chemical Equilibrium By Peer-Led Team Learning
Reguli, Ján; Čičmanská, Lenka, *Trnava University*, Slovakia

OC 80 Everyday Analogies To Understand The Concept Of Aromaticity
Simon, Silvia; Duran, Miquel; Solà, Miquel, *University of Girona,* Spain

OC 81 Enhancing Teacher Learning Using Solo Taxonomy
Tomperi, Päivi; Aksela, Maija, *University of Helsinki,* Finland

OC 82 Welcome-Science – Introduction For Refugee–Children In Language And Science
Lück, Gisela, *Bielefeld University,* Germany

20:45 – 23:15 **CONFERENCE DINNER. RESTAURANT MUSEU HISTÒRIA DE CATALUNYA**

Saturday 10th September

Room 1 Sala Prat de la Riba / Room 2 Sala Pere i Joan Coromines

08:45 – 09:40 **Plenary Lecture:**

PL 04 Inquiry and its Assessment – Lessons from Research and Practice
Odilla Finlayson, *Dublin City University,* Ireland

Room 1 Sala Prat de la Riba

09:45 – 11:00 **OC 8.1 Symposium** Language and Chemistry Teaching and Learning
Chairs: Silvija Markic, *University of Bremen*, Germany and Peter E. Childs, *University of Limerick,* Ireland.

S 14 LISP: the Language in Science Project
Peter Childs, *University of Limerick* and Marie Ryan, *Our Lady's Secondary School,* Ireland

S 15 Tertiary Chemistry Students' Understanding of language Items used in Chemistry Instruction
Roko Vladusic and Mia Ozicwona *University of Spli*t; Robert Bucat, *The University of Estern Australia,* Croatia

S 16 Write on the Edge: Using a Chemistry Corpus to Develop Academic Writing Skills Resources for Undergraduate Chemists.
Jacquie Robson, Megan Bruce, Philippa Coffee and Simon Rees, *Durham University,* UK

S 17 Chemistry Teachers pedagogical scientific language knowledge
Silvija Markic, *University of Bremen,* Germany

Room 2 Sala Pere i Joan Coromines

09:45 – 11:00 **OC 8.2 Oral Communications (OC 83 - OC 87)**
Chair: Dragica Trivic, *University of Belgrade,* Serbia

OC 83 Assessing Students' Progress In The Virtual Lab Using Trace Files And Rule-Based Analysis
Cuadros, Jordi; Martori, Francesc, *IQS Univ. Ramon Llull,* Spain

OC 84 Exploring Efficiency Of Systemically-Oriented Instruction In Chemistry Classroom: The 3-Dimensional Approach
Hrin, Tamara; Milenković, Dušica Segedinac, Mirjana; Horvat, Saša; Đekić; Jelica, *Faculty of Sciences, University of Novi Sad,* Serbia

OC 85 Zero Chemistry MOOC: Building Bridges Towards University.
Simon, Silvia; Duran, Josep; Guillaumes, Laia; Vieta, Josep Anotn; Rodríguez, Montse; Rafel, Sara; Heras, Montse; Duran, Miquel; *Universitat de Girona,* Spain

OC 86 Developing And Implementing Protocols In Quality Assurance To Enhance Educational Development In Tertiary Chemistry Education
Dolfing,Ria, Apotheker,J, *University of Groningen,* The Netherlands

OC 87 A Pedagogical Framework For Graduate Teaching Assistants To Promote Meaningful Learning In The General Chemistry Laboratory
Flaherty, Aishling; O'Dwyer, Anne; Erduran, Sibel, *University of Limerick,* Ireland

Room 3 Sala Nicolau d'Olwer

09:45 – 11:00 **OC 8.3 Oral Communications (OC 88 - OC 92)**
Chair: Jan Lundell, *University of Jyvaskyla*, Finland

OC 88 Real-time experiments to enhance Chemistry Competencies in Secondary. What does it make the difference?
Tortosa Moreno, Montserrat; Skorsepa, Marek; Smejkal, Petr ; Urban-Woldron, Hildegard; Guitart, Fina; Aksela, Maija; Stratilová-Urvalková, Eva; Tolvanen, Simo, *INS Sabadell,* Spain

OC 89 MBL inquiry experiments to enhance science skills and chemistry competencies at secondary school: Practice and research results
Guitart Mas, Fina; Artigas Oliveras, Carme; Tortosa Moreno, Montserrat, *University of Barcelona and CESIRE Departament of Education,* Spain

OC 90 Professionalization Of Future Chemistry Teachers For Teaching In Inclusive Classe
Melle, Insa; Schlueter, Ann-Kathrin, *TU Dortmund University*, Germany

OC 91 Inclusion In Chemistry Education In Secondary School
Melle, Insa; Michna, Dagmar, *TU Dortmund University,* Germany

OC 92 A Trail Over Conceptual Stepping Stones: Ancient Technologies And Models In Introductory Chemistry Course For 6-7 Grades
Vysotskaya, Elena; Khrebtova, Svetlana; Rekhtman, Iya, *Psychological Institute of the Russian Academy of Education, Moscow,* Russia

11:00 – 11:30 **Coffee Break – Cloister (Ground floor)**

BUS DEPARTURE FOR COSMOCAIXA SCIENCE MUSEUM (11:30 h)

Sala Àgora COSMOCAIXA Science Museum

12:30 – 13:25 **Plenary Lecture:**

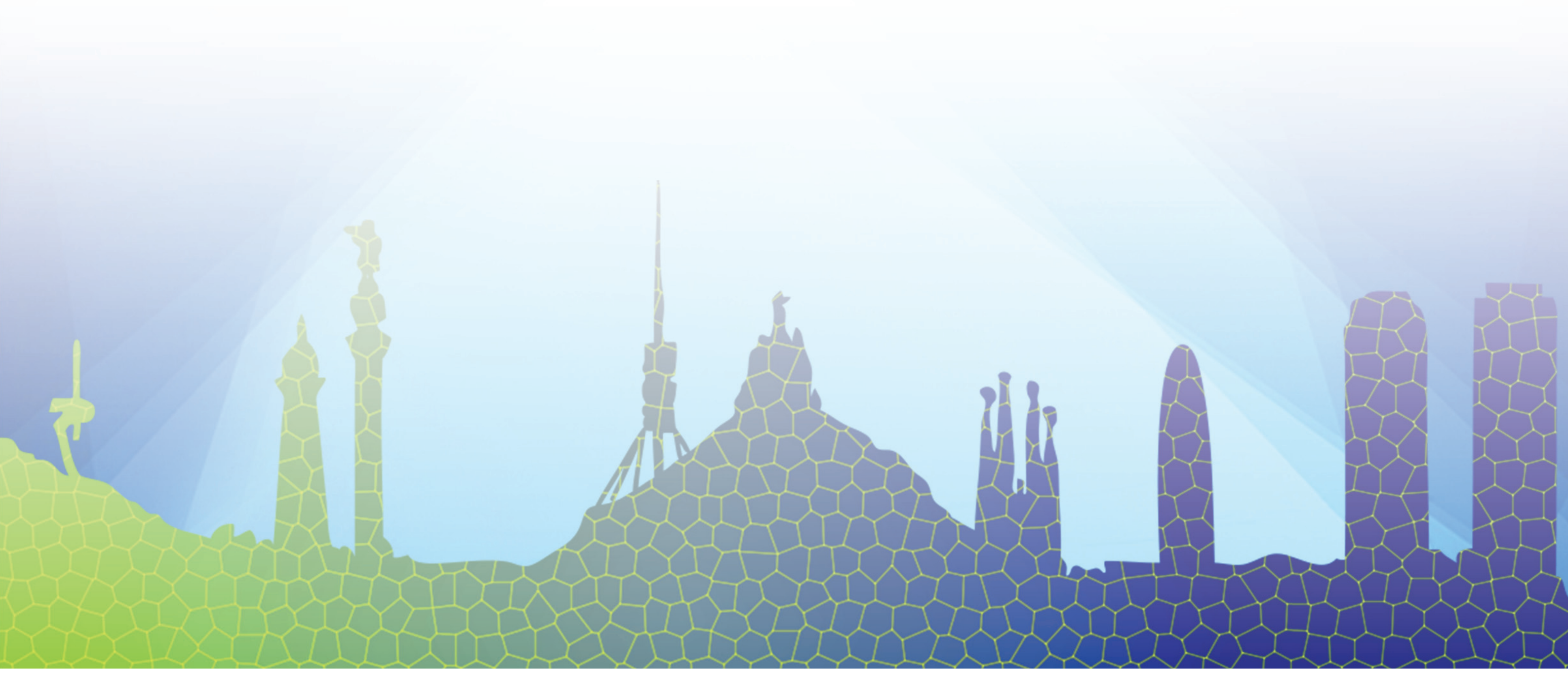
PL 05 Evidence-Based Approaches to Curriculum Reform and Assessment
Melanie M Cooper, *Michigan State University,* United States

Sala Àgora COSMOCAIXA Science Museum

13:25 – 14:00 **CLOSING CEREMONY**

14:00 – 14:30 **Farewell Appetizer at COSMOCAIXA**

15:30 – 16:30 **Guided tours to COSMOCAIXA Science Museum or Planetarium**
(Optional, see for inscription in Social Events)



Plenary *Lectures*

Online labs in science education, new possibilities for active student learning

Ton de Jong

Department of Instructional Technology, Faculty of Behaviorial, Management and Social Sciences, University of Twente, The Netherlands, Email: a.j.m.dejong@utwente.nl

Plenary presentation

Active learning is currently getting much attention because it engages students and also has proven to be a very effective form of science learning. Inquiry learning with online laboratories fits very well with this approach of active learning. In chemistry education online (virtual and remote) laboratories in addition have safety and environmental advantages but in this presentation I will focus on the pedagogical advantages of learning with online laboratories and discuss the inquiry processes of students and how these can be actively supported by technological means in the form of focused, flexible, and adaptive online scaffolds. An introduction will be given to the Go-Lab federation of online labs (www.golabz.eu). We will make a tour along all the facilities of Go-Lab including its scaffolds and we will experience how to create a scaffolded learning environment (Inquiry Learning Space) based on a chemistry lab with the Go-Lab authoring tools (www.graasp.eu). Empirical work assessing the effectiveness of online labs and scaffolds in particular will be presented.

Ton de Jong

Ton de Jong is professor of Instructional Technology at the University of Twente. He specializes in inquiry learning (mainly in science domains) supported by technology (online labs, games, modelling environments). He was coordinator of several EU projects (e.g., SimQuest, Co-Lab, KITS, SCY) and several national projects including the ZAP project in which interactive simulations for psychology were developed. ZAPs are sold worldwide. For ZAP and SimQuest he has won a number of international prizes. For one of the SCY applications the ***Inquiry Based Instruction*** prize issued by ***Science*** was won in 2013. Currently he is coordinator of the 7th framework EU Go-Lab project. He published close to 200 journal articles and book chapters, is associate for the Journal of Engineering Education, and is on the editorial board of eight other journals. He has published papers in ***Science*** on inquiry learning with computer simulations (2006) and online laboratories (2013). He is AERA fellow and was elected member of the Academia Europaea in 2014. For more info see: http://users.edte.utwente.nl/jong/Index.htm.

Learning science through contemporary research vs. using a historical approach

Rachel Mamlok-Naaman and Ron Blonder

Department of Science Teaching, Weizmann Institute of Science, Israel

Using a historical approach for science teaching is a well-established field (Mamlok-Naaman, Ben-Zvi, Hofstein, Menis, & Erduran, 2005). Numerous programs were developed around the world in which students are exposed to historical development of scientific ideas and models. Studies that have followed the implementation of these programs show that this approach supports students' understanding of the nature of science as well as their motivation to study science. However, some researchers claim that using the historical approach may not be the most effective model for science education. Currently there is a growing body of knowledge examining learning science through contemporary research and cutting-edge development of scientific ideas, e.g., nanoscience and nanotechnology (Jones, Blonder, Gardner, Albe, Falvo, & Chevrier, 2013). According to this approach, students have high interest and motivation to learn modern aspects of science, and they gain high-order skills and conceptual understanding as well. It should be noted that this approach is very challenging for science teachers, who need to continuously participate in professional development programs to update their knowledge. In our joint lecture we will present research results aimed at examining and comparing the two approaches. Different criteria are used for the comparison, starting from choosing the scientific contents, and following suitable pedagogies that accompany each approach. We will demonstrate how the different approaches deal with development of models in chemistry, how they convey the relationship between science and technology, and how they guide students and teachers to perceive the work of a scientist. Then, we will discuss the results of implementing the approaches in high school science classes, and finally, we will consider the following aspects: (1) What are the advantages of each approach? (2) What are the limitations? (3) How does each approach influence students' motivation and interest towards science? And (4) How are teachers influenced by these two approaches?

References

Mamlok-Naaman, R., Ben-Zvi, R., Hofstein, A., Menis, J., & Erduran, S. (2005). Influencing Students' Attitudes towards Science by exposing them to a Historical Approach. *International Journal of Science and Mathematics Education, 3*(3), 485-507.

Jones, M. G., Blonder, R., Gardner, G. E., Albe, V., Falvo, M., & Chevrier, J. (2013). Nanotechnology and nanoscale science: Educational challenges. *International Journal of Science Education, 35*, 1490-1512. doi:10.1080/09500693.2013.771828

How to engage students in and for science? Perspectives for school and out-of-school learning

Ilka Parchmann
Leibniz-Institute for Science and Mathematics Education (IPN), Kiel, Germany

Many initiatives have been developed to raise students´ interests in STEM careers, such as curriculum development programs, pointing out the relevance of science (context-based learning, CBL) and/or the excitement of scientific inquiry (inquiry-based learning, IBL), extracurricular learning opportunities like science competitions or the huge development of student labs with more than 300 registered labs in Germany (associated as "Lernort Labor"), to name one example.

However, demands for better qualifications and higher numbers of students are still reported. The huge investment in development programs has rarely been accompanied by research investigating effects and conditions of successful programs. Existing studies confirm interests in the different programs, but they do not provide evidence for long-lasting effects on students´ interest in science or technology careers, for example.

How can science education provide a better foundation for the development and implementation of programs that work and strengthen the area with long-term perspectives? How well are different activities connected, or do they sometimes rather represent parallel worlds for students?

The plenary lecture will explore the different fields of activities and the state of research on effects and conditions of successful school and out-of-school science enrichment activities. Beginning with programs aiming to raise students´ interest and engagement by regular science or chemistry classes, examples from the German initiative Chemie im Kontext and from two EU-projects, ESTABLISH and IRRESISTIBLE, will be given to point out how traditional subject-relevant topics can be well connected with context- and inquiry-based learning. Empirical results indicate effects on students´ interest in the topics, but still lack clear effects on future career perspectives.

Hence, out-of-school examples providing further enrichment and science communication opportunities will be presented and discussed in addition. Exemplary activities from a spectrum of activities with different goals for different groups of students has been implemented and empirically investigated with regards to students´ expectations and outcomes. Results will be shown from studies accompanying the Junior Science and the Chemistry Olympiad, a student lab program connected to a Collaborative Research Center and a project day at school.

In conclusion, demands for better links between different programs as well as between student and teacher education will be set and discussed. The network "student labs as learning labs for teachers" and its realization at the "Kieler Forschungswerkstatt" will be taken as one example for such a systematic approach.

Inquiry and its assessment – lessons from research and practice

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Inquiry-based science education (IBSE) has been the focus of many national and international programs and projects in Europe in recent years as its methods have been suggested as a way to develop students' knowledge and skills and extend their science learning. This paper discusses how assessment can be integrated within the IBSE framework.

Curricula and syllabus guidelines are changing in many countries across Europe. Many are introducing more active pedagogies in teaching, more engaging topics in the curriculum and more investigative and inquiry practices in the classrooms. These changes must also be accompanied by assessment practices that can assess the knowledge, skills and competencies that are developed. For many students and teachers, assessment drives the activities in a classroom. However, most current assessment methods have a strong emphasis on knowledge recall and do not address the crucial skills and attitudes dimension of key competencies. Moreover, if something is assessed, then it is more highly valued by teachers and students alike; hence, if the inquiry competencies and skills remain un-assessed, then the development of these skills and competencies will always be secondary to recall and routine problem solving.

This presentation will explore the interrelation between learning aims, teaching strategies and assessment practices within the context of an inquiry framework. While learning aims and teaching strategies are often considered in tandem, the strategies for on-going evaluation of the student learning are often only considered at the end of the process. Challenges of assessment in practice, the roles of assessment (Black, 2013) and how assessment influences the learning are discussed in this presentation. Particular examples of assessment in chemistry at both 2nd and 3rd level will highlight the different purposes of assessment, the value emphasised within the learning process and the opportunity presented by assessment strategies to guide and further learning. Taking the term assessment to cover 'any activity in which evidence of learning is collected in a planned and systematic way, and is used to make a judgment about learning' (Harlen & Deakin Crick, 2002), then the role of assessment in inhibiting or extending learning can be explored.

Building on international research in this area and the experience in practice, as evidenced through European projects (such as SAILS), the learning potential and variety of assessment opportunities will be discussed.

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SAILS project www.sails-project.eu

Evidence-Based Approaches to Curriculum Reform and Assessment

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There is now fairly large body of work from the learning sciences providing us with insights into how people learn; and from Discipline Based Education Research (DBER)[1] we know what discipline-specific difficulties students face. However, it is quite surprising that relatively little of this understanding has made its way into the design of science and engineering curricula offered at most colleges and universities. While there is much discussion of evidence based reform, most of these efforts are focused on incorporating pedagogical techniques[2], rather than redesigning the curriculum and the concomitant assessments of student learning in light of evidence from research. This presentation will focus on the need for evidence based curriculum reform, the research findings that can guide such reforms[3,4,5,6], and how we might assess the results of these reforms[7–10]. Examples of curriculum reform efforts and assessment strategies will be presented and will include: a new general chemistry curriculum, "Chemistry, Life, the Universe and Everything"[6], approaches to systemic reform that focus on core ideas, scientific practices and cross-cutting concepts[11,12], and approaches to the design of assessments that elicit evidence of student use of their knowledge[13].

Results of such transformation efforts indicate that students who participate in such transformed courses have a more robust understanding of important chemistry concepts such as the causes and consequences of intermolecular forces[9,10], structure property relationships[8,14], and acid-base chemistry.

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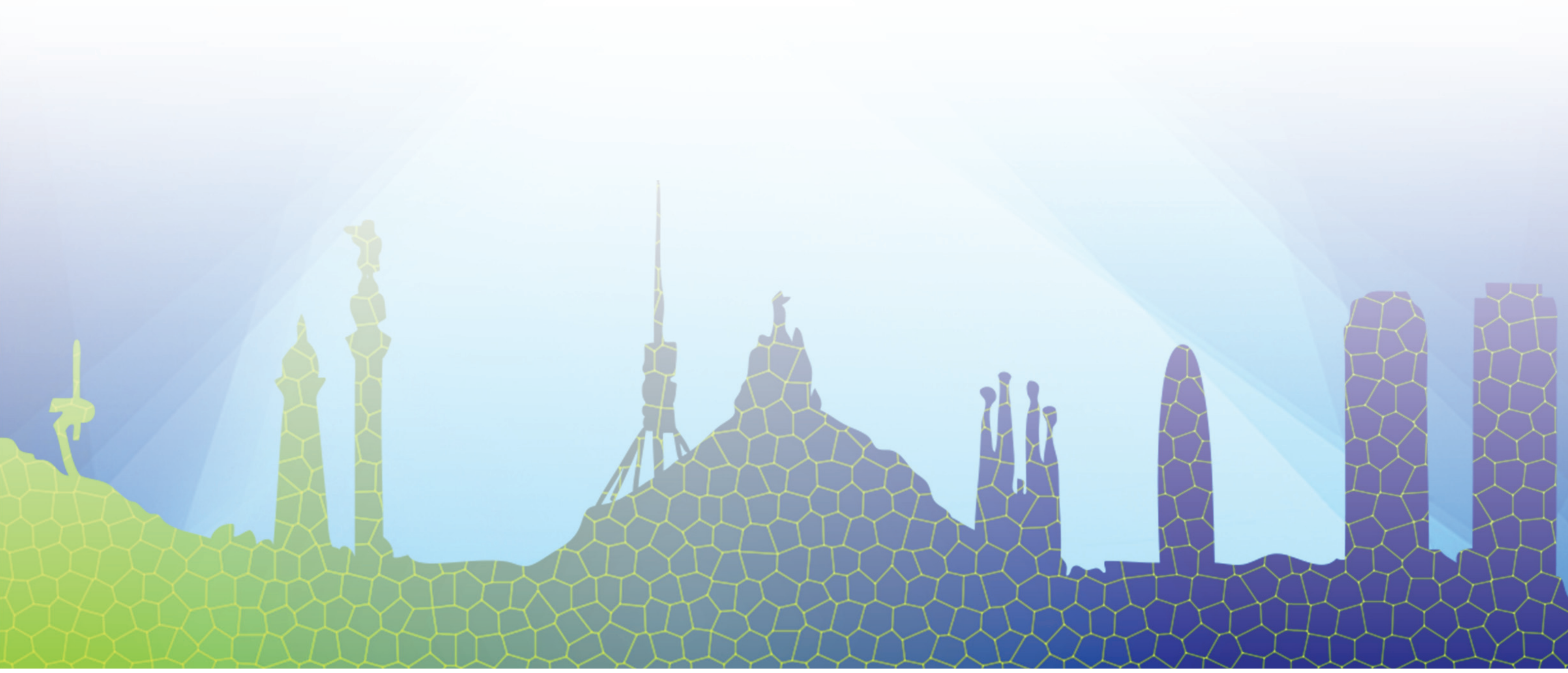

Keynote
Lectures

A new approach to Pedagogical Change: Research the Problem and Involve the Teachers in the Process

Diane Bunce

Keynote Lecture topic (inspiring innovative teaching methods to teach new generations with new challenges and improve chemistry education by taking into account research data in the field)

Abstract

Since formal teaching began, teachers have searched for ways to help their students learn. Through cognitive psychology, we now better understand that meaningful learning is more than memorizing the facts and processes of chemistry but rather results in reorganization of how the knowledge is stored in the learner's memory. Meaningful learning provides better access to that information and more effective interaction between topics. Rather than just implement the newest pedagogical approach to learning and then wonder why it is not as effective as hoped, we suggest that learning innovations must be better matched to the needs of the individual learning venue. We must understand the culture of the institution where change is sought. This is best done by field research on how and what kind of learning currently takes place in the specific class, course, or school. To do this we much involve the teachers as co-investigators in the analysis of the current teaching-learning situation. This baseline data collected to better ascertain the answer to a particular learning problem will be more effective in leading to a solution for the learning community in question. Reflection and evaluation of the results of this pedagogical change will help teachers know how to make decisions that will direct the future implementation of the pedagogical change. Involving the teachers as part of the research team, helps establish a reliance on data-driven innovations that has a better chance of effecting meaningful change within the class, course or school in question. This presentation will document how this approach to bringing about change through data-driven innovation by using field research with teachers as co-investigators at the US Naval Academy where 1000+ freshman are enrolled in the same general chemistry course for science majors has been implemented.

Keywords: Field Research, Teachers as co-Investigators, Data-driven innovation, Reflection and Evaluation

KN 02

Informal Chemistry Education: A missed opportunity?

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Science, Technology, Engineering, Mathematics and Medicine (STEMM) disciplines are increasingly shaping our lives and the world we live in. With this in mind there is concern that skills shortages could impact on national and global economies. Addressing challenges across these areas requires engaged and informed citizens and also a pool of STEMM professions, for the present day and the future. Policy documents (Rodriguez ***et al.,*** 2013; Special Eurobarometer 401, 2013), research institutes and funding bodies (SFI 2015) are increasingly requiring public engagement, believing it to provide a pathway towards research with impact (UK Research Excellence Framework (REF) 2014). However, there are issues with how researchers communicate to the 'public', with this communication being very much dependant on their ability to share and explain their knowledge in a meaningful fashion (Bray et al., 2012). Particular issues arise as researchers frequently presume a public deficit in knowledge of, attitudes towards, and trust in science (Bauer ***et al.,*** 2007)

This paper will focus on the bodies of research that shape this dialogue, specifically, attitudes towards science, public understanding of science, scientific literacy and work undertaken in the area of outreach and public engagement leading to informal and non-formal learning with a particular focus on chemistry related programmes. Outreach, public engagement and informal and non-formal programmes have been the 'go-to' vehicle for societal engagement across many levels (primary and post-primary pupils and teachers, community stakeholders, policy makers, general public), but there is not a 'one-size fits all model'. Assessment of activities and events tends to be superficial, and perhaps misses an opportunity to utilise these opportunities leading to real and meaningful engagement.

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Advancing Chemistry Education Research: Dual-Process Theories, Learning Objects and Student Response Systems

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Extended Abstract (Keynote Lecture)

Chemistry education research as a field is gradually advancing at university level. When speaking of ***chemistry educators*** and ***researchers***, two distinctive groups of expertise emerge. One group, Group I, is made of chemists in pure science. This group of experts conduct their research in chemistry and take teaching role for chemistry courses close to their expertise. Another group, Group II, is composed of chemistry educators, who teach introductory level chemistry courses and all levels of pedagogical courses. Research-wise, chemistry educators conduct social and behavioral research on teaching and learning of chemistry. While informing policy makers and practice of teaching, chemistry education research needs to embrace both the depth and breadth of issues in chemistry and pedagogy. Thus, to advance chemistry education research, it is imperative that both group of experts need to cooperate mutually.

One of the key obstacles today is falling interest of youngster's towards science, as recently reported by European Union. Huge efforts have been made towards better science teacher training across Europe. To support this action, the direction of chemistry education research should align the focus towards alternative and innovative methods for teacher training and practice of chemistry teaching.

In response to the need for innovative methods in chemistry education research, I propose two directions as outlined below.

Affective Domain. New theoretical perspectives on how affective factors are the determinants of decision-making process and their implications to chemistry learning and teacher training are of interest. My suggestion is to adapt *Dual-Process Theories* into chemistry education research context. Dual-Process Theories attempt to explain how behavior is generated through impulsive and reflective systems. The adaptation simply leads one to consider ***more affective aspects than usual*** and ***less cognitive aspects than usual***. Therefore, practice of chemistry education from both teaching and research perspectives will likely to be more human-friendly.

Educational Technology for Rich Interactivity. Advancements in computing power and reduction of their cost to individuals make educational technology more available to the public at large. This fact brings new opportunities for chemistry educators. The foci here are ***rich interactivity*** and ***self-study environments*** provided by the media through adaptive systems. Two emerging possibilities have been the topic of my recent projects at undergraduate level chemistry classrooms:

1. Easy deployment and use of *Learning Objects (LO)*, and
2. Integration of *Student Response Systems (SRS)*.

Both of these projects required me to closely work with chemistry professors (Group I) and so the projects provided enough room to merge our expertise for innovative chemistry education projects. *LO*s support high student interaction with chemistry content through adaptive feedback loops and sustain student engagement through self-study. On the other hand, *SRS*s support in-class interaction which is ideal for face-to-face instruction and developing two-tier instruments in the context of chemistry education research to discover student conceptions.

Acknowledgements

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- Physical chemistry education and learning objects: An implementation and development of the materials on inquiry-based approaches at higher education (Grant No. 2011/132)
- Impact of instructional interactivity in chemistry education (Grant No. SBA-2015-569)

An instructional framework for transforming authentic practices into contexts for the outline of chemistry curricula

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Abstract

The motive to start our work was to make chemistry education more meaningful to students who experienced that school chemistry was abstract, did not have a good connection to their life world and was difficult to learn (cf. Gilbert, 2006; Parchmann et. al, 2006). The idea was that learning chemistry using context should be a step forward to address this problematic situation (cf. Bulte & Pilot, 2006). However, it is not trivial to establish a meaningful connection between the context at the start of a unit and the introduction of specific chemistry content when designing a context-based approach (Bulte et. al., 2006).

Adopting the idea of social practices as a basis for chemistry education (Van Aalsvoort, 2004), we used authentic practices to select, specify, replace and/or modify specific chemistry content (Bulte et al., 2006; Meijer, et. al. 2009; Prins et. al., accepted). Actually, when analyzing authentic social practices, this led to a new focus on the selection of specific chemistry content for school science (Meijer et al., 2009; Sevian & Bulte, 2015). This has been recommended by Van Berkel et al. (2000) and more recently by Sevian and Talanquer (2014).

This paper describes the design-based research procedure we followed – starting from an authentic chemistry practices – to develop an instructional framework together with exemplary curriculum units. We show how the framework and the units were adapted as a result of the several cycles of experimentation. This framework is discussed in relation to other instructional frameworks.

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How to transform the learning of chemistry into relevant education

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Science teaching in general, and chemistry learning in particular can become relevant education for all learners when they contribute to general intellectual and educational skills development (Stuckey et al., 2013). Corresponding educational skills encompass capabilities for societal participation and for the sustainable development of the learners' individual and societal environment, e.g. communication and multidimensional evaluation skills (Marks & Eilks, 2009). That means relevant chemistry education needs to aim thoroughly also on skills that go beyond understanding content and processes from within chemistry or an understanding of the usefulness and meaning thereof, as suggested in the two visions of scientific literacy by Roberts (2007). This talk suggests that a vision III is necessary (Sjöström & Eilks, 2016) that goes beyond Roberts' vision II and that focuses more thoroughly on learning about chemistry and understanding the links between chemistry, environment and society. Beyond Roberts' content- and context-based visions, this vision III might be called a critical vision of scientific literacy (Sjöström & Eilks, 2016). In this talk, supporting theories and an organizer will be presented to justify chemistry education that aims thoroughly on skills preparing the learner for societal participation as part of education for societal participation and sustainability. Another organizer for identifying corresponding issues will be presented (Stolz, Witteck, Marks & Eilks, 2013) as different pedagogical innovations will be discussed along examples (e.g. Stuckey & Eilks, 2014) that might help to transform the teaching and learning of chemistry into relevant education.

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Studying Student Behavior and Chemistry Skills Using Browser-based Tools and Eye-tracking Hardware

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Abstract

Using technology allows an education researcher to collect quantitative data from larger cohorts and across several institutions. Several browser-based tools and accompanying data and interpretations will be presented. Eye-tracking hardware is another methodology to examine visual and graphical representations; examples will be presented.

A browser-based tool for generating general chemistry word problems has been used to examine the role of question complexity and cognitive load. A set of question variables were set by a software algorithm on each attempt and were analysed using logistic regression. Besides addressing the original research questions, difficulties with unit conversion were uncovered. Further insights into students' use of the tool came from the eye-tracking hardware—the analysis enabled comparison of times for reading, planning and calculations among cohorts separated into more or less successful students.

A browser-based tool has been used to probe student ability to draw Lewis structures using drag-and-drop to place atoms, electrons and bonds. Another similar tool allows students to drag-and-drop spheres to represent atoms, resulting in insight into their understanding related to the particulate nature of matter. Once again, eye-tracking hardware is used to examine aspects of the visual component of these activities.

The eye-tracking hardware has been used to examine the approaches used by introductory organic chemistry students and graduate students in their first few years of matriculation in solving proton NMR questions. These two groups, designated as novices and experts, use significantly different approaches to using the spectral data to pick the correct structure that matches the spectrum. Statistical differences appear in several aspects of trying to solve the problem, including the path (i.e., pattern of steps) utilized.

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Inquiry based learning: some results of research in Chemistry education in Portugal

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Abstract

The results of a Portuguese science curriculum evaluation study showed that teachers (where Physics and Chemistry teachers were included) didn't change significantly their practice, persisting in using teaching methodologies very far from the inquiry-based approach proposed in the curriculum. Data was collected through a national study, in which questionnaires were applied to a representative sample of students and science teachers. Taking these results as a starting point, I'll discuss the importance of raising the relevance of science to students and promote their knowledge on scientific activity, and also on problem solving, reasoning, communication skills, and decision making. I'll present some examples of tasks that were designed to make chemistry relevant to students and offering them a challenging learning environment, but also the results of a research to show what pupils have learnt by participating in it. In particular, the main goal is to show that tasks that promote their autonomy, and emphasize inquiry, making use of society context-oriented approaches may work as a very promising context for pupils' science learning. These tasks were developed within European projects, i.e. PARSEL (Popularity and relevance of science education for scientific literacy) and SAILS (Strategies for assessment of inquiry learning) and have been tested in the participant countries of these projects.

Key words

Chemistry education; inquiry based learning; relevance of science topics; context-oriented approach.

Undergraduate Chemistry Laboratory: Goals and Novel Assessments

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We have carried out a program of research focusing on determining faculty and student goals for laboratory since 2006 (Bruck, Bretz, Towns, 2008; Bruck, Bretz, Towns, 2009; Bruck, Towns, Bretz, 2010; Bretz, Fay, Bruck, Towns, 2013, Bruck & Towns, 2013. The faculty perspective has been investigated via a mixed methods study to articulate the goals, strategies, and assessments used in undergraduate teaching laboratories. The results have allowed us to discuss faculty goals across the curriculum with an understanding of broader goals such as critical thinking skills and experimental design, and as well as differentiating across the curriculum where faculty in place less emphasis on research like experiences and writing skills in general chemistry than other courses in the chemistry curriculum. The student goals in many cases and their actions in laboratory do not correspond well with faculty goals for the curriculum (DeKorver & Towns, 2015; DeKorver & Towns, 2016). Additionally, we have found evidence that students are not carrying forward laboratory skills throughout the chemistry majors curriculum. These findings have encouraged the development of a novel method of assessing hands-on laboratory skills known as digital badging (Riconscente, Kamarainen, Honey, 2013; Towns, Harwood, Robertshaw, Fish, O'Shea, 2015), . We have developed, implemented, and assessed three digital badges in our curriculum and will discuss the impact on student knowledge, confidence, and experience using pipets, burets, and volumetric flasks.

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Promoting holistic sustainable development through chemistry teacher education

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Chemistry teacher education has a central role in educating teachers about promoting the principles of sustainable development and thus building a brighter future for the upcoming generations. In the holistic education of sustainable development, the following four points of view of sustainable development are taken into consideration: ecological, economical, social and cultural. In this presentation, it is discussed with examples, how we can promote sustainable development and the basic and further education of teachers within formal and non-formal education. This presentation illustrates the building of a communal strategy of sustainable development and its implementation in science teaching in the University of Helsinki's Unit of Chemistry Teacher Education in the Department of Chemistry collaborating with LUMA Centre Finland. As examples, the following are presented: (i) A multidisciplinary course "Sustainable development in education" carried out student oriented, (ii) the content of another course "Circular economy in chemistry teaching" carried out in collaboration with the industry, (iii) an international multidisciplinary massive online course (MOOC) on the teaching of sustainable development, (iv) an international Teachers' Climate Change Forum, (v) an international project-based learning program called StarT for schools, and research concerning these above mentioned examples. The Unit of Chemistry Teacher` Education is engaged in the Finnish "Society's Commitment to Sustainable Development 2050" campaign.

Figure. Information about the international LUMA activities for ESD education:
Teachers' Climate Forum and StarT: http://www.luma.fi/news

Virtual and real environments interaction in chemistry education

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Short Abstract

How to blend real and virtual experimenting in chemistry education? The paper deals with design and results of research project oriented to analysing possibilities and limits of the virtual environment in experimental activities learners in lower secondary chemistry education (laboratory work with real (manual) and virtual (simulated) pH-meter).

The ICT implementation to the process of chemistry instruction does not mean eliminating real school experiments from school laboratory practice. The real living environment makes us face more and more items of virtual environments, worlds, mediated by infinite possibilities of computer networks. The mediated perception through virtual images has become an important cognitive channel for pupils. Real information from the existing reality is steadily replaced by virtual information. Is the remote (by computer network mediated) and virtual (by computer simulated) chemical experiment able to meet requirements of the best school laboratory practice? How to blend an effective and meaningful application of real, indirect and simulative observation, measuring and experimenting according to didactic principles? Researching these fields leads, or not, to proving intuitive estimations, which is important, as well as answering other questions resulting from this area of potential assets and threats. It is obvious that nowadays, in the period of creating and applying remote, especially virtual, laboratories and their accessibility also in extra-curricular conditions via Web, there is an increasing demand for new researches (mainly pedagogical and pedagogical-psychological ones) in this field.

Design one of our research project was oriented to analysing possibilities and limits of the virtual environment in experimental activities learners and teachers especially in chemistry, which serves as an example of natural science instruction. We obtained few interesting results relating to chemistry education supported by ICT on lower secondary education. The research activity was oriented to working with real and virtual (simulated) pH-meter. After measurements learners were tested on their level of knowledge and asked to express their opinion on other possibilities of pH measuring with laboratory devices. Pupils working with real devices (manual pH-meters) related their proposals to their practical applications which frequently appear in everyday life. On the contrary, pupils working with virtual devices (Web-applets) were kept fully engaged in this virtual environment. Either situation, i.e. whether they belong to the real or virtual world, influenced learners´ opinion substantially. In case of work in virtual environment their relation to the real environment was restricted by the computer screen and keyboard to a large degree.

Results and findings from realised project were a big motivation for continuing similar research projects, examining other examples of virtual worlds (different animations and simulations in different didactical scenarios) and next examples of their use in different types of instructional design.

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The development of pre-service chemistry teachers' pedagogical content knowledge through research activities

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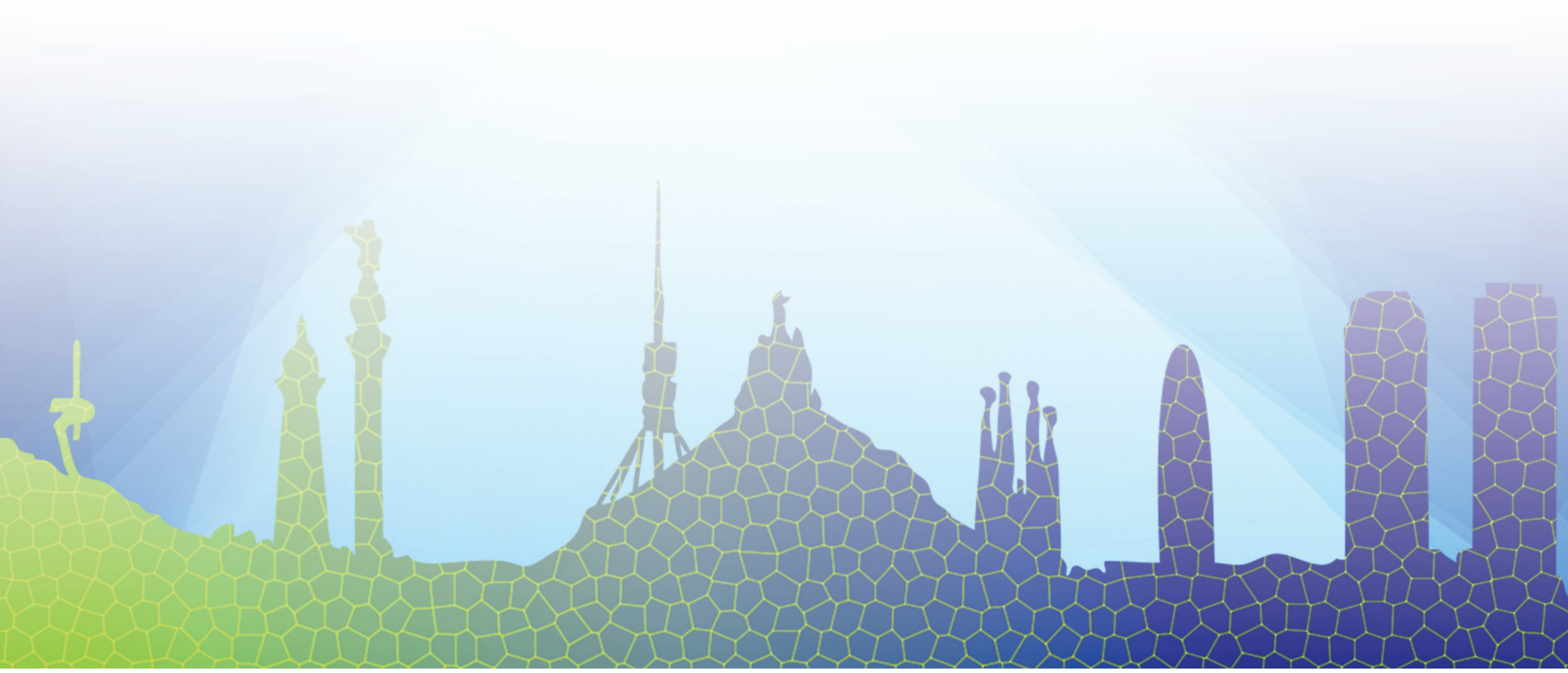
An important part of the development of chemistry teacher competences associated with the requirements of current education policy is their research activities. Accordingly one of the challenges posed to teacher educators relates to how to frame their university courses in such a way to ensure that future teachers be familiar with different contexts and appropriate methodology, be trained to reflect upon their own preconceptions and thus refine their own understanding of the processes of chemistry teaching and learning. Pedagogical content knowledge (PCK) serves as the basis for teachers to transform various domains of their knowledge into a new quality according to the different curricula for primary and secondary schools, teaching/learning goals, standards, students' needs, their abilities and interests.

During past decades the development of PCK of future chemistry teachers had the different position in the structure of curriculum for pre-service chemistry teachers' education at the University of Belgrade – Faculty of Chemistry. Also the contents and activities related to the development of PCK during that time were changed. At the beginning the research activities of future chemistry teachers in chemistry education domain were placed at the end of their studies. Namely, in the framework of preparation of bachelor and master theses students had the opportunity to explore the efficacy of different approaches and to compare learners' achievements in relation to the applied teaching/learning methods, or the used teaching aids, instructional texts, or the place where the lesson was held, etc.

The recent changes in the curriculum for pre-service chemistry teachers' education have incorporated the research activities of students – future chemistry teachers into the earlier phases of their education and the new course of school practice with the educational research was introduced. In the framework of this course the students prepare the research projects, conduct research, collect and elaborate data and write an article. The research provides students with a process that involves reflection based on received results, utilization of a systematic inquiry for future data based decision making. After that students have opportunity to present their findings to colleagues on the mini symposia as a part of regular classes. The approach enable them the additional reflection according to received feedback in discussion with other students and colleagues from Faculty. This cycle of reflection and action enables the students to develop deeper understanding of what chemistry concepts are difficult for primary and secondary school students to learn, the effects of application of different instructional materials and teaching/learning methods, etc.

Results of the incorporation of described activities into the curriculum of pre-service chemistry teachers' education indicated that students have built the important base of knowledge and experience for further development of PCK and better prepared themselves for the upcoming courses according to the curriculum, as well as for the final theses preparation. In the future it would be important to create a system for monitoring how this approach to chemistry teachers' education reflects on their practice.



Chemical *Demonstrations*

Nanotechnology experiments for general chemistry laboratory classes

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This author has utilized low-cost nanotechnology experiments, and related demonstrations, in the non-major and general chemistry laboratories that were modified from procedures from multiple sources and kits developed at the Materials Research Science and Engineering Center (MRSEC)[1] at the University of Wisconsin-Madison. These experiments include both gold and silver nanoparticles, cholesteryl liquid crystals, both pressure and temperature sensitive, a liquid crystal "pixel", a microcrystalline titanium dioxide solar cell, aqueous Ferrofluid, properties of LEDs, and working with and training Nitinol metal[2]. The hands-on experiments along with discussions of applications of these experiments give students, both majors and non-science majors an understanding of nanotechnology and how it affects them in their daily lives. In addition, some nanotechnology materials, particularly cholesteryl liquid crystals and Nitinol metal materials, have been used in presentations for children and the general public in presentations in science museums.

References

[1] MRSEC Video Lab Manual can be accessed at http://education.mrsec.wisc.edu/nanolab/index.html
[2] Procedues can be accessed at http://www.chymist.com/Laboratory%20Experiments.htm under the sub-heading Nanotechnology experiments.

React… Explode! From alchemists to catalysts through experiments you can do in the classroom

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Abstract

React… explode! is a project developed by researchers and professors at Department of Chemistry of the Universitat de Girona to fight against the lowering of interest in Chemistry by high school students. The use of recreational chemistry and the explanations and demonstrations by University researchers in high school class are the pillars of this project.

The story

The use of experiments is a good way to attract the attention of preuniversitary students. In this presentation, several classical experiments are used to illustrate the evolution of chemistry.

Starting with a magic experiment in which earth and water are mixed to obtain air and water, the alchemist explains how dragoons make fire in his mouth.

Boyle published "the chemist sceptic" to finish the magic and hide era of alchemy. He studied the gases and participated in the discovery of phosphorus.

The first chemist, Lavoisier, focused the attention in chemical methodology, measuring the results of his experiments. He studied mainly oxygen and nitrogen, the combustion and the concept of acid and base. The experiments shown will be based in these subjects.

The invention of steam engine by Watt drove the first industrial revolution. Although it is a technological invention, the energy used is chemical. The combustion of charcoal and the aluminothermy are two reactions related to railway. Thermite reaction will be showed as an example of chemical reaction used in railroad track.

Green chemistry is an actual tendency in industrial and academic research. The main goal is to find sustainable and environmental friendly chemical processes. The use of catalysts allows obtaining products economizing reagents and using less energy. Toothpaste elephant is the chosen reaction to show the role of a catalyst.

Inquiring energy through simple experiments: a differentiation of concepts to strengthen energy literacy

Klemens Kock
Fachdidaktik Chemie, Pedagogical University of Berne, Switzerland

Energy is a concept much more complex than we possibly teach it to most of our students. To improve the understanding of the energy problems and the energy turnaround we have to focus more on the quality of energy and not only on its quantity. Energy consumption does not reduce the quantity of energy but its quality.

Three simple experiments illustrate the more subtle aspects of energy, especially in the way the energy concept is used in chemistry.

- The first experiment shows a new variation of the well-known reaction between sodium carbonate and citric acid emitting carbon dioxide. It is followed by the opposite reaction using calcium oxide to absorb the carbon dioxide. The experiment shows why enthalpy is a more convenient concept than energy for chemical reactions. One chemical reaction is releasing energy in form of pressure-volume-work and the opposite reaction is gaining the same amount of pressure-volume-work.
- The second experiment demonstrates the fundamental difference between work and thermal energy by tensioning and releasing a rubber balloon. Additionally it shows how heat and cold are released and that creates interesting links to changes in aggregation state and to a refrigerator.
- The third experiment shows a very simple but modern aluminium-air battery concept. It explains the principles of galvanic cells releasing the most important form of energy: work. It offers a lot of ways to investigate how it works and how it works better.

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"In a little you can see a lot": The impact of practical microscale chemistry on chemical education

Robert Worley FRSC, MSc, BSc
Chemistry Adviser (semi-retired) to CLEAPSS in the United Kingdom

UNESCO1 promoted microscale techniques in over 70 countries, to involve children in practical work where there are few laboratory facilities.

However, practical microscale chemistry has made little impact on teachers in the United Kingdom who have, for over a hundred years, supervised and carried out practical experiments safely, due to the expertise in teachers trained in traditional chemistry techniques, trained technicians and activities of a singular organization in the UK, namely CLEAPSS2.

CLEAPSS consists of a small group experienced science teachers, financed by subscription of employers and independent schools, that works closely with the Department for Education and the UK Health & Safety Executive, to ensure that teachers, school technicians and students work safely during science practical lessons. In order to minimize risk and reduce costs both in monetary and environment terms, and in compliance to EU and UK safety law, CLEAPSS has pioneered new and novel procedures in all sciences. In chemistry, CLEAPSS have used micro-chemical procedures to make lessons more efficient and concise. However, for these techniques to be acceptable to UK teachers, there has to be "added value"3.This comes in improved classroom management, reducing cognitive load on the short term-working memory, challenging long-held misconceptions with regard to chemistry at the molecular/ionic level and even developing completely new experiments for students and demonstrations for teachers.

This presentation will summarize this "added value" with live demonstrations, a small exhibition of equipment and videos of microelectrolysis (Fig 1), diffusing precipitates (Fig 2), and simple equipment (Fig 3). The procedures have been collected and adapted from the support and work of various enthusiasts of micro and small scale chemistry around the world such as Bruce Mattson4 David Katz5 (US) Jorge Ibanez (Mexico), John Bradley (South Africa) and many others.

With modern, yet inexpensive, IT facilities there are still plenty of wonderful images6 to inspire students and present images that require subtle, yet important, interpretation.

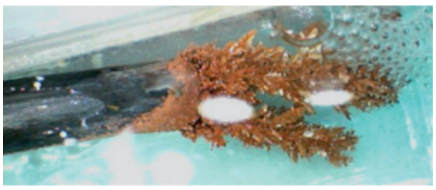

Fig 1. Copper growing from the cathode during electrolysis

Fig 2. Copper carbonate precipitates in a 2cm puddle of water

Fig 3. The mini Hoffman Voltameter

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5 http://www.chymist.com/
6 www.microchemuk.weebly.com

APQUA Project: 25 years of integrated inquiry-based, issue-oriented and hands-on science education in grades 4-11

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1. Introduction. APQUA (Aprendizaje de los Productos Químicos, sus Usos y Aplicaciones) is an IBSE educational project that has been underway in Spain since 1989. The project is the result of a collaboration between SEPUP (Science Education for Public Understanding Program) of the Lawrence Hall of Science of the University of California at Berkeley, and the Universitat Rovira i Virgili in Tarragona.

The main goals of APQUA are to develop greater awareness and public understanding of chemical products and processes and their relationship to our lives and to promote the use of scientific principles, processes, and evidence in public decision making. APQUA develops activity-based instructional strategies and materials, and provides them to schools and community groups through the School Program, aimed at 9-17 year-old students, the Community Program (Science Shop) and the Educational Site Visits Program.

APQUA's approach to science education is presented in this communication. The module "Plastics in our Society" is given as an example, information is provided about partnership, results, and some results of the assessment studies made by the APQUA staff are explained.

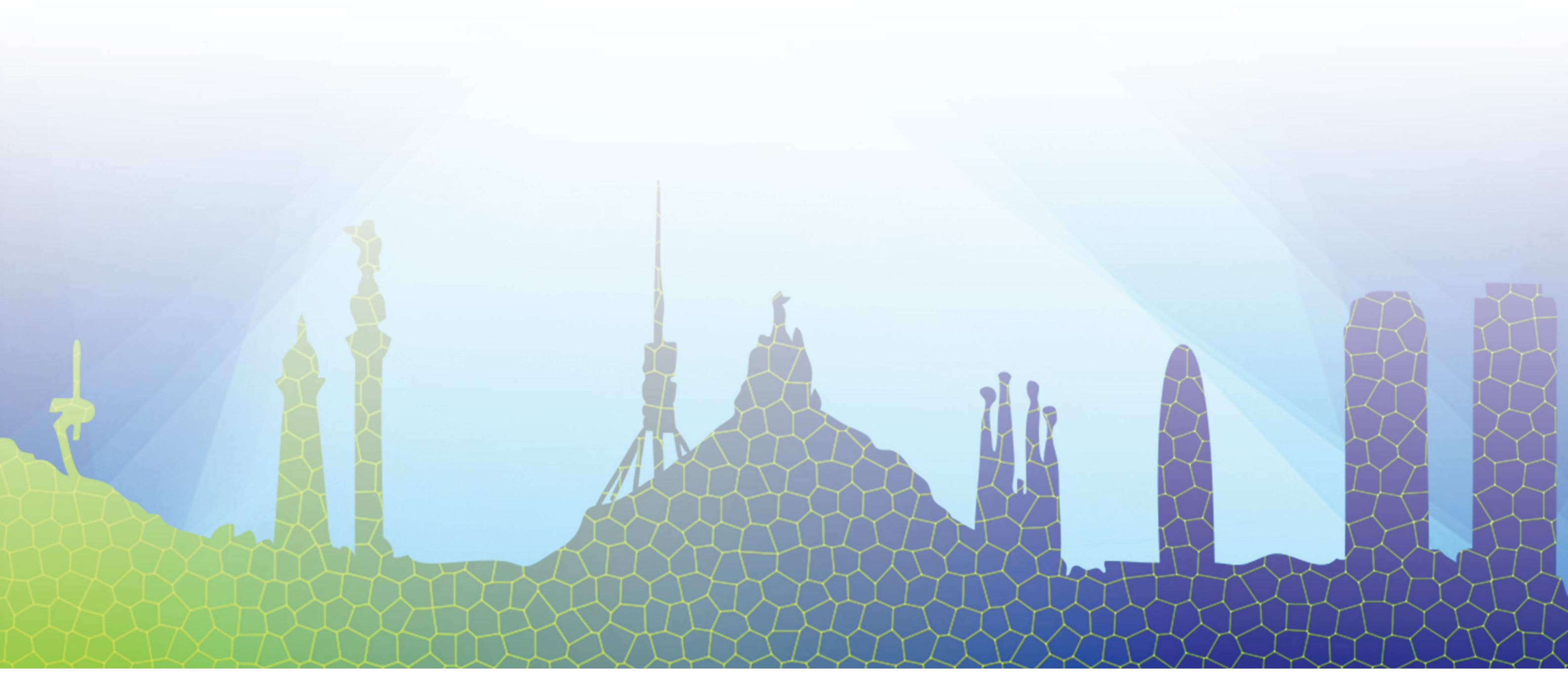
2. APQUA approach. The APQUA School Program approaches the learning of science through studying and discussing current issues. The materials are organized into modules, consisting of various work activities in which open questions are asked, situations simulated and experiments provided (guided inquiry and cooperative teamwork model). These tools integrate scientific competences and contents, and problem-solving skills, so that students can make personal decisions. The aim is for students to develop their comprehension and judgment on scientific issues and the limitations of science. To APQUA, learning science in the classroom does not involve merely reading a book; it involves activities, questions, discussions and debates. Each module is designed to be used in the classroom and consists of a guide for teachers and students, and specific material such as trays, dropping bottles, stirrers and funnels.

3. The "Plastics in our Lives" module. In this module, designed for grades 9-10, students act as members of a board that has to propose a material so that a company can manufacture a container. This means that they have to investigate plastics in depth, make a comparative analysis of the life cycle of different materials and finally make a decision using all the evidence obtained. It also provides information about organizing site visits, a tool for assessing the progress of students' in a particular scientific competence and tools for improving literacy. The module is available in paper and online versions, both of which follow APQUA's methodology and interactions.

4. Partnership, results and accomplishments. APQUA is the result of a partnership in which the university is solely responsible for the stablishment of objectives, content and methodology; public authorities and private companies support the research involved in project development, contribute to the diffusion and provide technical informaton; and schools collaborate in the development of the modules and testing in the classroom. By way of example, the module presented has been developed with the support of the association PlasticsEurope and 28 in-service secondary-school teachers.

Between 1989 and 2015, a total of 260,000 students in 1,533 schools, and 9,000 adults used APQUA modules; 6,446 teachers trained in 328 workshops; 15,000 students and 1,500 adults participated in 600 educational site visits; and more than 20 Science Shop projects were carried out.

Several assessment studies have been made and two doctoral theses have been published about the Project. In brief, the School Program improves the science-teaching methodology because it favors student-teacher interaction, increases use of extra school resources, helps in the implementation of hands-on activities and fosters the process of asking questions. It also enhances small group and class discussions and student decisions, both dealing more with industrial and environmental issues, social and health problems, and improving the students' attitudes toward science. Finally, it changes the students' perception of industry, because it gives them a broader, less biased, and more realistic point of view.



Symposiums

SESSION/ DATE	TITLE SYMPOSIUM/	CHAIR
OC1.1 (SYMPOSIUM) **Wednesday 7th September** **14:15 h -15:30 h**	**TOWARDS *MORE* RELEVANT CHEMISTRY EDUCATION**	Ingo Eilks, University of Bremen, Germany and Avi Hofstein, The Weizmann Institute of Science, Israel
TITLTE		**AUTORS**
S 01. Towards eco-reflexive and transformative learning in chemistry education		Jesper Sjöström, Malmö University, Sweden
S 02. Medicines in my Life: An authentic contextualised module for pupils and teachers		Sarah M. Hayes, University of Limerick, Ireland
S 03. From students' chemistry interest in internet forums to classroom practice		Johanna Dittmar and Ingo Eilks, University of Bremen, Germany
S 04. Directions and obstacles regarding research, development, and practice for relevant chemistry education		Avi Hofstein, The Weizmann Institute of Science, Israel and Ingo Eilks, , University of Bremen, Germany
SESSION/ DATE	**TITLE SYMPOSIUM/**	**CHAIR**
OC4.1 (SYMPOSIUM) **Thursday 8th September** **14:15 h -15:30 h**	**TEACHER TRAINING MADE IRRESISTIBLE**	Sevil Akaygun, Bogazici University, Turkey
TITLTE		**AUTORS**
S 05. Understanding responsible research and innovation: perspective of teachers		Jesper Sjöström, Malmö University, Sweden Sevil Akaygun, and Emine Adadan, Bogazici University, Turkey
S 06. Science teachers' training in implementing cutting-edge research topics in science classes		Katerina Salta, Emily Michailidi and Dimitris Stavrou, University of Crete, Greece
S 07. The use of a community of learners as a professionalization tool		Iwona Maciejowska, Malgorzata Kzeckowska Jagiellonian University, Krakow
S08. Teachers' concern profiles in teaching Responsible Research and Innovation		Miikka de Vocht, Antti Laherto, University of Helsinki, Findland and Ilka Parchamann, University of Kiel, Germany
SESSION/ DATE	**TITLE SYMPOSIUM/**	**CHAIR**
OC6.1 (Symposium) **Friday 9th September** **14:15 - 15:45**	**THE IRRESISTIBLE WAY TO ENGAGE SCHOOL STUDENTS WITH RRI**	Jan Apotheker, University of Groningen
TITLTE		**AUTORS**
S 09. The project Irresistible: Introducing Responsible Research and Innovation into the secondary school classroom.		Jan Apotheker, University of Groningen
S 10. The Rationale of Responsible Research and Innovation (RRI) in Science Education		Ron Blonder, Shelley and Sherman Rosenfeld, Weizmann Institute of Science, Israel
S 11. Irresistible exhibitions on responsible research and innovation: the impact of the process of exhibition development on both students and teachers		Rita Marques, Patrícia Azinhaga, Pedro Reis, Elisabete Linhares and Mónica Baptista, Lisbon University, Portugal
S 12. Exploring students' motivation while creating a student curated exhibition		Lorenz Kampschulte, Daniela Ingwersen, and Ilka Parchmann, Leibniz Institute for Science and Mathematics Education, Germany
S 13. Exploring Students' Attitudes toward Responsible Research and Innovation in the Context of Nanotechnology Applications Module		Emine Adadan, Sevil Akaygun Bogazici University, Turkey

SESSION/ DATE	TITLE SYMPOSIUM/	CHAIR
OC8.1 (SYMPOSIUM) **Saturday 10thSeptember** **9:45 - 11:00**	**LANGUAGE AND CHEMISTRY TEACHING AND LEARNING**	Silvija Markic, University of Bremen, Germany
TITLTE		**AUTORS**
S 14. LISP: the Language in Science Project		Peter Childs, University of Limerick ans Marie Ryan, Our Lady's Secondary School, Ireland
S 15. Tertiary Chemistry Students' Undestanding of language Items used in Chemsitry Instruction		Roko Vladusic, University of Split, Croatia, Robert Bucat, The University of Estern Australia, and Mia Ozicwona, University of Split, Croatia
S 16. Write on the Edge:Using a Chemistry Corpus to Develop Academic Writing Skills Resources for Undergraduate Chemists		Jacquie Robson, Megan Bruce, Philippa Coffee and Simon Rees, Durham University, UK
S 17. Chemistry Teachers pedagogical scientific language knowledge		Silvija Markic, University of Bremen, Germany

Symposium (OC1.1)
Towards *More* relevant chemistry education

Symposium Chairs: Prof. Ingo Eilks PhD[1] & Prof. Avi Hofstein PhD[2]

[1]Institute for Science Education, University of Bremen, 28334 Bremen, Germany

[2]Department of Science Teaching, The Weizmann Institute of Science, Rehovot, Israel

'Relevance' is one of the key terms when it comes to the teaching and learning of chemistry. It is used by policy makers, curriculum developers, science education researchers, and chemistry teachers. Generally, it is claimed that chemistry education is often perceived (especially in the secondary level of schooling) as being irrelevant to the learners, and maybe it is indeed. Policy papers and the literature suggest that making chemistry education relevant to the learner personally and to the society, in which he or she operates, is one of the key goals for modern chemistry learning. However, it seems not always to be clearly or adequately conceptualized what is meant by 'relevant'. A review of the literature clearly shows that the term 'relevance' is used with different meanings (Stuckey, Hofstein, Mamlok-Naaman & Eilks, 2013). On this base Stuckey et al. suggested a comprehensive definition of the term 'relevance' in science education. They also outlined a model covering the different dimensions of relevance in science education, namely individual, societal and vocational relevance with each having both a present to future and an intrinsic to extrinsic dimension. They also provided guidance for its use in the field of the science curriculum.

Based on the work by Stuckey et al. (2013), Eilks and Hofstein in 2013 invited 40 chemistry education scholars from all over the world to use the model and contribute their perspectives on what is making the teaching and learning of chemistry relevant to the learner and how to operate corresponding practices. The introduction to the symposium will briefly introduce the different meanings and the comprehensive definition of relevance. It will name the issues covered already in the book by Eilks and Hofstein (2015) named 'Relevant Chemistry Education – From Theory to Practice'.

However, the symposium is not thought to sum up what was already captured by the book. It intends to add new perspectives and further directions of how to raise the relevance of chemistry education and students' perception thereof. Contributions will cover new views concerning chemistry on sustainability education and transformative learning (J. Sjöström), outreach, formal and informal learning connections (S. M. Hayes), informal student learning and critical media literacy education (J. Dittmar), the effects of learning chemistry when being oriented along the different dimensions of relevance (M. Hugerat), and directions for future activities in teacher professional development, assessment and research (A. Hofstein).

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Towards eco-reflexive and transformative learning in chemistry education

Jesper Sjöström PhD
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The modern society can be described as a globalized risk society (Beck, 1992) characterised by increasing complexity and unpredictable consequences of techno-scientific innovations. One example is the "chemicalisation" of our society and bodies. Therefore modern citizens need science and chemical literacy to make informed decisions on sustainability issues (Sjöström, Rauch & Eilks 2015). Scientific literacy is a well-established concept in the science education literature and includes knowledge about (a) scientific concepts and models, (b) the nature of science, and (c) the role of science in society. Traditionally, focus has been on (a), but in recent decades more focus has been put on (b) and (c) (Aikenhead, 2006). A teaching focusing on scientific literacy may have different complexity from being merely technically oriented, via being socio-economically oriented, to being also value-oriented (Pedretti & Nazir, 2011). The same goes for chemistry education, which can have different complexity going from fundamental chemistry, via simple contextualization, to multifaceted problematization (Sjöström & Talanquer, 2014). Such a complex and relevant form of scientific and chemical literacy may be referred to as new Vision III of scientific literacy (Sjöström & Eilks, 2016). It is oriented towards complex sustainability issues, critical perspectives and action competence (Hodson, 2011). Bildung-oriented chemistry education (Sjöström, 2013) is based on such a vision of chemical literacy. Bildung is an educational ideal for citizens and has been described as a central critical concept of modern pedagogy. Bildung-oriented chemistry education covers ethical and political dimensions and focuses on meta-perspectives and socio-political actions grounded in a problematizing stance towards the modern risk society (Sjöström, 2013). To this can be added an understanding of the complexity of life and society and their interactions, and a responsibility for both individual and collective actions towards socio-ecojustice and global sustainability. Together with colleagues I recently introduced the term "eco-reflexive" for such an approach (Sjöström, Eilks & Zuin, under review). In this presentation I will, except giving a short theoretical background, discuss the implications of eco-reflexive Bildung on chemistry teaching and learning. This orientation can be seen as a merging between the fields of Chemistry Education (CE) and Environmental and Sustainability Education (ESE) (Wals, 2010). In the latter field "transformative learning" is an important concept (Thomas, 2009).

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Medicines in my Life: An authentic contextualised module for pupils and teachers

Sarah M. Hayes PhD

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This research utilises a number of educational approaches, incorporating teaching and learning through a contextualised module with dual informal and formal teaching approaches. Previous work carried out into the area of informal learning and Transition Year Science (Garner, Hayes & Eilks, 2014; Hayes & Childs, 2013) indicated the value of context-based, relevant and authentic materials, with a focus on career orientation and mixed teaching and learning methodologies. This led to the development of a module entitled 'Innovation in Medicine' aimed at pupils (aged 15-16) and teachers in post-primary education. In addition to this work a second phase to the project incorporates informal and formal education, as there are many barriers which prevent schools, communities and the wider general public accessing the work carried out by large scientific research centres. Yet community action is frequently considered a major aspect of scientific literacy (Hodson, 1998; Roth, 2003).The combination of the 'Innovation in Medicine' module with a community action approach has led to the 'Medicines in my Life' project. This offers a platform through which to translate the research conducted in a scientific research centre and engage across formal and informal learning environments, bringing science into the community. Pupils and teachers working with the 'Innovations in Medicine' module are invited to showcase the relevance of their learning through devising and presenting an exhibition as a means of transforming science from product to process (Hawkey, 2001). During these exhibits' preparation, learners will ask questions, use logic and evidence in formulating and revising scientific explanations, recognising and analysing alternative explanations, and communicating scientific arguments. The main objectives of this project are:

To increase understanding of the nature and importance of research to society, for culture, economic development, attracting industry investment and creating jobs.

To expose more young people to a wide variety of research advances in a relevant manner that will interest them, and develop an awareness of and interest in how research is conducted, who carries out the work and how it is used.

To develop teachers' expertise about how to broaden school experiences in relation to cutting edge scientific and technological issues through the construction of exhibitions centred on such issues

The evaluation of this project utilises a mixed methods approach in order to achieve a holistic view of whether the objectives have been achieved. As such, the methods utilised are 'fit for purpose', employing both quantitative and qualitative measures. Qualitative measures have been interviews and focus groups with teachers and pupils, and pre- and post- pupil surveys. Data from this project is currently being analysed and promises to yield interesting insights into pupil and teacher experiences of relevant contextualised science education.

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From students' chemistry interest in internet forums to classroom practice

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In today's society the importance of digital media is continuously increasing. E.g. in Germany, more than 90% of all households have Internet access via computers, tablets or laptops, with 92% of the young generation aged twelve to nineteen have own smartphones. For the young generation the Internet is the key to search for information about everyday problems or more general issues (mpfs, 2015). Information is mainly searched for by search engines, such as Google. Quite often links are provided by the search engines to Internet forums where everyday problems or general issues are discussed. This information is also connected to classroom science learning when it comes to issues related to science and technology, such as cosmetics, health or environmental issues. This turns the use of digital media into a challenge for science teachers and science classroom practice. On the one hand, teachers need to be aware about the information and discussions students have in mind when it comes to corresponding science learning. On the other hand, education in general and science education in particular need to provide the young generation to access science related information in Internet forums in an informed, critical and reflective way (LMZ, 2007) as media education in general is suggested to be a cross curricular goal for all school subjects (UNESCO, 1982).

This presentation reports a study of analyzing what topics do students discuss in Internet forums. Based on the analysis evidence based pedagogies and lesson plans are jointly developed with teachers based on a participatory action research approach (Eilks & Ralle, 2002). The aim is that students learn about how science related information is approached in Internet forums. A special pedagogy is applied inspired by the structure and use of Internet forums. An example on "Mineral water vs. tap water" will be presented. In the lesson plan, a critical review of Internet forum posts provides input for chemistry learning, but a forum itself is used for exchange and discussion among the students in a cooperative teaching and learning scenario. Activities include search for information, discussion and practical work, as well as working with charts and tables.

Experiences and student feedback will be reported. Students generally enjoy working with and about Internet forums. The pedagogy contributes to make chemistry learning appearing modern and authentic. The exchange and debate by the students in a forum is perceived positive and the students feel strong involvement.

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Directions and obstacles regarding research, development, and practice for relevant chemistry education

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Last year we edited a book (Eilks & Hofstein, 2015) in which 40 authors from 16 countries wrote chapters all focusing on different issues, problems and pedagogies related to the issue of relevance in the areas of teaching and learning chemistry. A model by Stuckey, Hofstein, Mamlok-Naaman and Eilks (2013) for the various components of relevance was suggested to be used as being the advance organizer for the book (see the 1st chapter in the book). The key goal of the book was to provide the chemistry education community theoretical justification and practical guidance for promoting more relevant chemistry education.

While many advocate the importance of relevance it is suggested that there are several obstacles for effective implementation of programs, modules, and curricula that have potential to include the three key dimensions of relevance namely: individual, societal, and vocational relevance of science education. The three obstacles that might inhibit the effective implementation are: The professional development of chemistry teachers, the assessment of student's achievement and progress, and valid and reliable educational research methodology of these dimensions and its related areas.

This presentation will focus the three obstacles and will outline further directions for chemistry education

1. Professional development of chemistry teachers

In recent years we are observing attempts to change the way chemistry teachers are trained (both pre-service as-well-as in-service) to become effective chemistry teachers for more relevant chemistry education. However, as outlined in Stuckey et al. (2013) the concept of relevance behind some of the initiatives is not always clear. Even more, in many countries around the world teachers are still trained in the purist way namely teaching the "structure of the chemistry discipline."

2. Assessment of students' achievement and progress.

There are examples that in cases in which the three relevance dimensions are integrated and in the formal chemistry curriculum the assessment of students both during the learning periods as-well-as in final examination does not really focus both personal, societal and vocational relevance or the perception thereof.

3. Research projects

While many publications and essays advocate the term 'relevance', unfortunately it is suggested that the research into many variables (e.g. achievements, attitudes, interests, problem solving, teachers' professional development and inquiry) all related and aligned to the relevance topic is overlooked.

These thoughts will be further outlined during the presentation.

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Symposium (OC 4.1)
Teacher Training Made Irresistible

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Teachers' professional development (PD) is defined as "activities that develop an individual's skills, knowledge, expertise and other characteristics as a teacher" (OECD, 2009, p. 49). For many teachers, PD is a need; thus it is expected to be effective. As it is described in OECD's (2005) comparative review on teachers, "effective professional development is an on-going process that includes training, practice and feedback, providing adequate time and support. According to Kedzier (2004), the characteristics of high quality PD includes being content-focused, extended, collaborative, ongoing, inquiry-based, coherent & integrated, and teacher-driven. One of the systems used for teachers' PD is Communities of Learners (CoL) which have been considered to be a powerful means for teachers education (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010).

Project Irresistible (www.irresistible-project.eu), a project funded by European Commission, developed 10 different teaching modules in cutting-edge science topics integrating Responsible Research and Innovation (RRI). In the process of development and implementation of the modules teachers were involved in their local CoLs, which were composed of scientists, science educators, and museum experts, who met regularly and worked in a supportive environment.

This symposium will present studies investigated the impacts of being involved in a Community of Learners (CoL) on teachers from different perspectives. There will be four communications to be presented. The first talk, entitled "**Understanding Responsible Research and Innovation: Perspective of Teachers**" will be given by **Akaygun** and **Adadan**. The authors will focus on the exploratory findings of Turkish teachers' perspectives on RRI and their experiences of teaching RRI as a consequence of the implementation of their module. The second talk, entitled "**Science Teachers' Training in Implementing Cutting-Edge Research Topics in Science Classes"**, will be presented by Salta, Michailidi and Stavrou. They will present paper a study focused on a CoL implementing two of the Irresistible modules in Greece, and discuss their results on the teacher's training by expert-teachers in implementing cutting edge research-topics integrating RRI issues and the process of the development of exhibits by students. The third presentation will be given by **Maciejowska** and **Krzeczkowska**, and the title of the presentation is **"The Use of a Community of Learners as a Professionalization Tool"**. In her talk, the author will present findings Polish teachers' involvement in CoL, specifically focusing on the changes in the self-assessment of teachers' own competence; how the cooperation in the CoL affected the teachers' perception and attitudes; if the teachers think that they have developed new skills, e.g. carrying out IBSE according to the 5 E sequence; if the teachers find it easier now to talk to students about cutting-edge science and science itself. The last talk, entitled **"Teachers' Concern Profiles in Teaching Responsible Research and Innovation"**, will be given by **De Vocht, Laherto, and Parchmann**. The authors will report the results of their analysis on the concerns and interests of a total of 250 chemistry, physics or biology teachers, who participated in a 2-3 month professional development program, Irresistible, to create teaching modules containing aspects of Responsible Research and Innovation in the context of cutting-edge science such as nanotechnology or climate research. All in all, this symposium aims to report a various aspects of a teacher training model, Community of Learners, for the case of Project Irresistible.

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Understanding responsible research and innovation: perspective of teachers

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Within the last decades, the progression of science has changed its focus from "science in society" towards "science for and with society" (Owen et. al., 2012) through the recognition of a new construct Responsible Research and Innovation (RRI). Von Schomberg, (2011) defines RRI as "a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the ethical acceptability, sustainability and societal desirability of the innovation process and its marketable products" (p.9). In this respect, RRI has becoming an essential component of scientific improvements because they all affect society, hence require public involvement. Sutcliffe (2011) identifies six key dimensions of RRI; public engagement, science education, gender equality, ethics, open access and governance.

Recently, European Commission has taken RRI in their agenda and has been funding projects focusing on RRI in various contexts. Project Irresistible is one of the projects funded through SiS.2013.2.2.1-1 (Raising youth awareness to Responsible Research and Innovation through Inquiry Based Science Education), where several modules integrating RRI in cutting-edge science topics have been developed and implemented to primary and secondary school students by their science teachers.

As a part of Project Irresistible, in the year 2015-2016, three modules, on nanotechnology applications in health sciences, plastics in the oceans and climate change were implemented by the science teachers. Each module was introduced to teachers through 1 or 2-day workshops where they were modeled all the activities which include RRI-integrated scientific content. A total of 38 teachers participated in this study by taking a questionnaire in the beginning and at the end of the implementation of their module. In addition they were interviewed to gain a deeper understanding of their perspectives of RRI which was a new topic for them. This communication reports exploratory findings of teachers' perspectives on RRI as well as their experiences of teaching RRI.

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Science teachers' training in implementing cutting-edge research topics in science classes

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Research shows that students' interest is attracted and they learn more effectively when scientific topics are up to date, based on current research and related to their everyday life (Ellis et al., 2005; Hodson, 2013). These requirements are in general realized in the project Irresistible with the involvement of students, science researchers and science museums in the process of Responsible Research and Innovation based on cutting edge – research topics (RRI, European Commission 2012).

In the context of the Irresistible project in Greece, in the first phase five highly qualified and experienced in-service teachers of primary and secondary education developed and implemented a teaching module on RRI issues using topics from the fields of Nanoscience and Nanotechnology (NST). The teachers were active members in a "Community of Learners" (CoL) consisting of two science education researchers, two nanoscience researchers and three science museum experts. In a second phase under the supervision of the five teachers of the first phase (expert-teachers) 32 teachers (11 primary teachers and 21 secondary teachers) participating in new CoLs (each one involving one expert-teacher and 5 to 10 (out of the 32) teachers) are called to implement in total three of the Irresistible modules developed in the first phase in Greece and in partner countries: a) NST Applications (Greece), b) Plastic–Bane of the Oceans (Germany) and c) Healthy ageing starts with mammae (Netherlands).

In the present paper we will present a study focused on a CoL implementing two of the Irresistible modules in Greece, in particular: NST Applications (Greece) and Healthy ageing starts with mammae (Netherlands). At the beginning of the current school year a kick-off meeting took place where teachers were informed about the main axes and objectives of the Irresistible project. After the meeting the participants answered to six open ended questions in a questionnaire about their expectations from their participation in the project and their needs to implement the chosen module. Subsequently, CoL meetings took place consisting of three main parts: (1) reflection on teachers' needs (2) clarifying the framework of the modules (3) discussing and working on the teachers' individual needs arising from the implementation of the module in their classroom. In addition to the CoL meetings, the participants also received individual support through one-to-one meetings and e-mail feedback from the expert-teacher. So far six meetings were conducted and the study will be completed in April with the exhibition of students' exhibits. Results about the teacher's training by expert-teachers in implementing cutting edge research-topics taking into account RRI issues and in the process of the development of exhibits by students will be presented in the conference.

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The use of a community of learners as a professionalization tool

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The study of both direct effects and the opinions of teachers has demonstrated that not all forms of CPD are equally effective. For example, Richardson (2003, p. 402) believes that professional development will be valuable if, among other things, it is long term, it encourages collegiality, and it acknowledges the participants' existing beliefs and practices. One of the answers to the question on how to ensure compliance with the above listed requirements may be to create professional learning communities (Gulamhussein, 2013). Several types of communities may be distinguished: a) a Community of Learners (CoL), b) a Community of Practice (CoP), c) a Community of Interest (CoI). They have different composition, different mode of action, although sometimes their goals are similar, including the support and development of competence of a given group and/or the co-creation of educational innovations and their implementation, as well as critical reflection (Krzeczkowska et al., 2015).

A Community of Practice has been used in the FP7 SAILS project, and a Community of Learners in the IRRESISTIBLE project. In the latter case, it has been used in as many as two phases of the project. In Phase 1, ten modules on various RRI topics have been developed by inhomogeneous, national CoL1 groups. The CoL is composed of school teachers, education experts from universities, exhibition experts from museums/science centres and researchers representing various fields, e.g. chemistry, biochemistry, biology, geography ***(IRRESISTIBLE home page)***. In Phase 2, each teacher taking part in the first phase led a new group of CoL2 which consisted of about five people (other teachers). The research conducted by the members of CoL1 that operated at the JU Faculty of Chemistry for eighteen months has shown that not only the teachers learned something new but, according to the basic assumption though surprisingly for sceptics, also other community members – in that case, the academics (Maciejowska & Apotheker, 2015). The authors of this presentation wanted to learn about the changes in the self-assessment of teachers' own competence; to see how the cooperation in the CoL affected the teachers' perception and attitudes; to learn if the teachers think that they have developed new skills, e.g. carrying out IBSE according to the 5 E sequence; if the teachers find it easier now to talk to students about cutting-edge science and science itself. For this purpose, structured interviews have been conducted, the conclusions of which will be presented in this speech. It was important to address the two roles of the teachers – CoL1 participants, who in Phase 1 came across numerous new concepts, methods etc. for the very first time, while in Phase 2 ran the CoL2 groups themselves, offering others their experience gained in the previous phase.

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Teachers' concern profiles in teaching Responsible Research and Innovation

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Teachers' attitudes play a key role in the diffusion of a teaching innovation (van Driel, Beijaard, & Verloop, 2001). Some teachers are active and enthusiastic, while others are skeptical and passive in their search for novel approaches. This study analyzed the concerns and interests of 250 teachers, who were mostly chemistry, physics or biology teachers in ten countries in all school levels. Teachers participated in a 2-3 month professional development program, IRRESISTIBLE, to create teaching modules containing aspects of Responsible Research and Innovation in the context of cutting-edge science such as nanotechnology or climate research. This study aims to improve the Concerns-Based Adoption Model (C-BAM), which assumes that teachers' interests and concerns are key-indicators of the success of a teaching innovation (Hall, George, & Rutherford, 1977; Shoulders & Myers, 2011). We improved C-BAM and a related questionnaire based on our study carried out in 2014-2015. In the current study (2015-2016) we carefully formulated 30 items and created variables measuring interests and concerns in six stages. Based on a cluster analysis teachers had four different interest-types and four different concern-types. By combining these types, we got 16 different profile types including e.g. the Realist, the Enthusiast, the Headstrong, the Humble, the Reformer and the Unconfident. The results suggest that teachers are a diverse group who need support in different areas regarding professional development. On average European teachers feel quite competent, want to find more collaboration with teachers and experts within and outside their own school, and do not see practical or informational issues as a problem when it comes to teaching of Responsible Research and Innovation. These claims were also supported by teachers' responses to open-ended questions. The C-BAM can be used in the future to identify teachers' needs related to a specific teaching innovation. Another application could be increasing the understanding of cultural differences between teachers from different countries. In international initiatives it is important to know, e.g. that science teachers in South Africa have different needs and concern profiles than science teachers in the US or Netherlands.

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Symposium (OC 6.1)
The IRRESISTIBLE way to engage school students with RRI

Jan Apotheker
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In this symposium we plan to show how to introduce cutting edge science research into the secondary school classroom. Not only the content of the research is introduced, but students are asked to apply principles of Responsible Research and Innovation towards this new science content.

Part of the project is the building of exhibitions in which the students demonstrate their knowledge. In the exhibition students demonstrate to the public what they learned. In some cases the focus of the exhibition can be that the audience can form an opinion about the issues presented, e.g. the use of perovskite solar cells as windows in a school'.

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The project Irresistible: Introducing Responsible Research and Innovation into the secondary school classroom

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Aims: The project IRRESISTIBLE designs activities that foster the involvement of students and the public in the process of responsible research and innovation. We raise awareness about RRI in two ways:

- Increasing content knowledge about research by bringing topics of cutting edge research into the program
- Fostering a discussion among the students regarding RRI issues about the topics that are introduced.

In a so called Community of Learners researchers, teachers, experts from science centres as well as educational researchers worked together in the design of educational material, that connects both in informal as well as formal learning environments.

The thematic modules are based on an Inquiry Based Science Education approach. We used the 5 E method designed by Bybee (Bybee, Powell, & Towbridge, 2007)as a starting point but added a 6 E called Exchange to foster the transfer of knowledge between the students, as well as between students and other stakeholders. In the first part of the module the science content is introduced, using a context in which the science research plays an important role. In some cases the students are introduced in a role they have to play. In that case the RRI components are part of the whole modules. In the other modules, the six key issues of RRI are introduced to the class in the second part of the module. In the exchange phase the students build an exhibit to be shown either at school or in a science centre, demonstrating the science content, the RRI-issues and active citizenship competences.

Findings: In ten countries modules were developed, all being successful in introducing cutting edge research and connected RRI issues.

In general the modules were successful in introducing the science research at a level understandable for school students and also to a much broader audience, through the students' planned exhibits. The students became aware of RRI dimensions that are part of any modern scientific research and innovation and were able to linking RRI issues to the introduced science research.

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The Rationale of Responsible Research and Innovation (RRI) in Science Education

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Responsible Research and Innovation (RRI) stands at the centre of several EU projects and represents a contemporary view of the connection between science and society in the EU commission. The goal of RRI is to create a shared understanding of the appropriate behaviors of the European Commission, governments, business and NGOs which are central to building trust and confidence of the public and other stakeholders in safe and effective systems, process and products of innovation (Sutcliffe, 2011).

Von Schomberg (2013) defined RRI as "a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)." RRI is built of six dimensions (Sutcliffe, 2011): 1. Engagement; 2. Gender Equality ; 3. Science Education; 4. Open Access; 5. Ethics; and 6. Governance. The integration of these dimensions is recommended in order to improve RRI.

In this lecture we will describe the development of our understanding the RRI construct and how to implement RRI in science education. In addition we will present the development process of an assessment tool to measure teacher and student attitudes towards the importance of the six RRI dimensions, as well as their ability to apply their RRI understanding on a controversial contemporary scientific subject. Ten project partners have used this tool to assess teacher and student attitudes before and after their exposure to the learning modules. In the symposium we will present this RRI assessment tool and the resulting students' attitudes in different EU countries.

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Irresistible exhibitions on responsible research and innovation: the impact of the process of exhibition development on both students and teachers

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The European Commission, in order to bring citizens closer to science, has been focusing its action on the Responsible Research and Innovation (RRI) theme. The IRRESISTIBLE Project arises in order to involve teachers, students and the public in the RRI process by implementing, in the classroom, activity modules developed by the several Comunities of Learners (CoL) of the Project. Each module involves students in the development of exhibitions on scientific cutting-edge topics. Hence, students and teachers have the opportunity to contact with topics that highlight a frontier science, that is controversial, uncertain and under debate. The exhibition, understood as an education initiative for other citizens, represents a context and pretext for students and teachers to participate in community action on controversial socio-scientific issues, encouraging the involvement of others. The community action based on research can be considered an important dimension of scientific literacy (Hodson, 1998; Roth, 2003).

In the 2014/2015 school year, in each of the ten partner countries of the Project, the activity modules were implemented and, as a final result, several exhibitions on RRI were developed by students and presented to the community. In order to better understand the process of exhibition development and to evaluate its impact on both students and teachers, each partner has developed one case-study focusing on one particular exhibition, gathering data through semi-structured interviews of both the teachers and students involved in the exhibition development. Each case-study described the process of exhibition development, identified the main difficulties experienced by teachers and students along the process, as well as the main learning achievments, and revealed the most positive and negative aspects resulting from the process of exhibition development.

This communication as the purpose to make known the results from the analysis of the 13 case-studies, and to conclude about the impact of the development of IRRESISTIBLE exhibitions on both teachers and students. The analysis of the case-studies followed a qualitative approach through content analysis methodology.

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Exploring Students' Motivation while creating a Student Curated Exhibition

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Developing an exhibition at school is a new approach for students to get in touch with science. For the students involved in creating an exhibition on a scientific issue, the process provides the possibility to intensely reflect on the topic – ideally in a broader, multifaceted way. Beyond that, the exhibitions created offer an informal learning situation for other students at school, or even for parents, friends and the public.

Within the IRRESISTIBLE project (www.irresistible-project.eu), student curated exhibitions are not only used to summarize and recapitulate the content learned in a preceding teaching unit, but also to present topics of cutting edge research to a broader community. A special focus of the IRRESISTIBLE project is on Responsible Research an Innovation (RRI), which is present in the themes that are controversial, uncertain and under debate, and reflected in the student exhibitions.

The process of 'exhibition making' offers learning opportunities for students that are extremely versatile, the topics can be illuminated from very different angles and with variable depth (D'Acquisto 2006). However, it is hardly investigated with regard to the outcomes and the conditions fostering a succesful development process.

Following a series of exhibitions developed within the IRRESISTIBLE project, built on a framework system specially designed for student curated exhibitions (www.exponeer.de), a huge diversity in approaching and presenting the topics could be observed. During the development process, case studies had been carried out to observe the process and to investigate the students´ motivation as one important factor for success; since motivation is known to be an important precondition for learning success (Decy and Ryan 1993). The main goal of the analysis was to find obstacles in the project flow, to streamline students' process of creation and to improve the integration in school schedules.

Two measures were used to gather the data: a post-questionnaire item asking students to self-rate their motivation during the different project phases, as well as a concept-map based interview that was performed during the day the exhibition was built to find factors advancing and/or hindering motivation to improve the project flow. Both measures indicate group dynamics having the largest influence on the motivation of the students, not only in form of "team work" within the group, but even more in terms of guidance and feedback through the teacher. Further, aspects like "science is fun" or "getting a broader view on the subject presented" were classified as motivational by the students. A more detailed analysis of the motivational factors will be presented in the talk.

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Exploring Students' Attitudes toward Responsible Research and Innovation in the Context of Nanotechnology Applications Module

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In recent years, with the introduction of the concept of responsible research and innovation (RRI), the role of science in society changed into science for and with society (Owen et al., 2012). The concept of RRI has greatly directed EU policies and also become an important dimension of research in European Commission's Science in Society Program. The project IRRESISTIBLE is one of the EU funded projects that aimed to address the aspects of RRI while teaching the cutting-edge science topics through inquiry. In the current study, a module involving nanotechnology applications in health sciences was developed in cooperation with science educators, a scientist, and science teachers. The main theme of the module was the antibacterial effect of silver nanoparticles. During the implementation of the module, students started with examining the basic ideas relevant to nanoscience (e.g., size and scale, properties of matter, and tools, Stevens et al., 2009). They also tested and explained the antibacterial effect of silver nanoparticles and then the changing amount of silver nanoparticles in nanoproducts as they are washed. Finally, students read about the properties of other nanoparticles (e.g., gold nanoparticles) and also discussed the aspects of RRI, namely public engagement, science education, gender equality, ethics, open access, and governance (Sutcliffe, 2011), by considering the nanotechnology in society, in particular the use of silver nanoproducts to be protected from bacterial infections. In this context, the purpose of the study was to examine middle school and high school students' attitudes toward responsible research and innovation as they involved in nanotechnology applications in health sciences module.

A total of 175 students participated in the study. Fifty six (29 male; 27 female) were middle school students, and 119 students involved from high school (69 male; 50 female). A five-point likert-type questionnaire with 12 items, namely Questionnaire to Measure Attitudes on Research and Innovation in Today's Society, was originally developed within the framework of IRRESISTIBLE project. The questionnaire included items for all six aspects of RRI. Data were collected as pre and posttest and in-between students were engaged in the inquiry tasks designed for the module. Data were analyzed by utilizing the statistical procedures (descriptive and inferential). This paper communicates the statistical results based on the data from the questionnaire by comparing and contrasting students' attitudes toward RRI from pre to posttest.

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Symposium (OC 8.1)
Language and Chemistry Teaching and Learning

***Chair:* Silvija Markic**
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***Discussion*: Peter E. Childs**
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The problems that the languages of chemistry present to the learner have been known for many years, since the pioneering work of Alex Johnstone in the 1980s. The teaching and learning of chemistry is intimately bound up in the language used, whether for reading or writing, speaking or listening. There are several dimensions to the question of language in addition to the acquisition of technical vocabulary. For example, there is the symbolic language of chemistry and mathematics, the use of non-technical/everyday words, the use of logical connectives and the formal structure of academic texts. All of these present problems to learners and are not all explicitly recognized or addressed by teachers. In addition, teaching and learning chemistry assumes a basic proficiency with the first/native language and this cannot now be assumed, especially with greater heterogeneity in European classrooms and lecture halls. The problems are not confined to second level but are also prevalent at third level, especially for students taking up chemistry for the first time or are planning to be chemistry teachers. The symposium will present research in the area and also ideas for successful teaching strategies and methods.

For presenters will focus on this issue:

1. **LiSP: the Language in Science Project**

Dr. Peter E. Childs & Dr. Marie Ryan

Childs and Ryan describe the LiSP project in Ireland aimed at lowering the language barriers in junior secondary science.

2. **Tertiary chemistry students` understanding of language items used in chemistry instruction**

Roko Valdusic, Dr. Rober Bucat & Mia Ozic

The authors will present a study which is on evaluation of student teachers` understanding of scientific language.

3. **Write on the edge: Using a chemistry corpus to develop academic writing skills resources for undergraduate chemists**

Dr. Jacquie Robson, Dr. Megan Bruce, Dr. Philippa Coffer & Dr. Simon Rees

The authors will present a workshop developed as a dissertation module to support students` writing skills.

4. **Chemistry Teachers` Pedagogical Scientific Language Knowledge**

Dr. Silvija Markic

The author will present the concept of pedagogical scientific language knowledge and the first evaluation of it.

LiSP: the Language in Science Project

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The multiple languages of science present a problem in the teaching and learning of science, especially in junior secondary school, where most students meet formal science for the first time, and for second-language learners (Childs, Markic & Ryan, 2015). Students meet many unfamiliar technical words in chemistry, for example, and a strange, symbolic language of chemical formulae and equations. Many everyday words undergo metamorphosis and have different meanings in science and beginners have to try and decode their meanings. The Language in Science project, LiSP, at the University of Limerick attempts to address such issues in junior secondary school (JSS) by a focused set of resources and strategies (Childs & Ryan, accepted). It is in JSS that most students meet formal science for the first time. This paper will describe the project and evaluate its effectiveness in improving students' learning and mastery of the language of science. The project also aims to raise science teachers' awareness of the language issues in teaching science, and these issues continue into senior secondary school and into university. Recognising the problem and implementing appropriate teaching and learning approaches, is a necessary and vital part of the science teachers' work. This is especially so for students with poor language skills and the greater diversity and heterogeneity of school classrooms and university lecture halls in 21st century Europe, makes attending to the language barrier in teaching and learning science even more important (Childs, 2016).

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Tertiary Chemistry Students' Understanding of Language Items used in Chemistry Instruction

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To communicate chemistry at university level, both teachers and students need to have rich science and everyday vocabulary. Wellington and Osborne (2001) noted that every science lesson is a language lesson. It implies that new terms can be introduced only if more basic terms are already understood. Teachers usually presume that students understand previously introduced words and symbolic representations.

Awareness of the quality of students' understandings of terms regularly used in chemistry can be of crucial importance in achieving learning outcomes. Following that idea, the research of tertiary chemistry students' understandings of scientific and everyday words and symbols used in chemistry instruction was conducted at the Faculty of Science, University of Split, Croatia.

The research is partially based on studies which provided evidence that non-technical vocabulary (Gardner, 1972; Cassels & Johnson, 1980 and 1985; Marshall, Gilmour & Lewis, 1991; Johnstone and Selepeng, 2001; Farrell and Ventura (1998), and especially technical vocabulary (Lynch et al., 1979; Meyerson et al., 1991) pose problems for students. The methodology used in the study reported here is specific in that understanding was investigated with several differently designed tasks, by two diagnostic instruments. The language of instruction was Croatian.

Students were asked to create a sensible sentence that includes the key term; explain the meaning of the key term in scientifically contextualized sentence; recognize the most appropriate meaning of key terms in everyday context, explain meanings of key terms and symbols given without context and choose correct meaning of several symbolic representations and expressions.

It was found that students involved in this study have problems with understanding of scientific words, everyday words and symbols used in chemistry teaching. There are considerable differences in level of understanding, from term to term. Several examples of language issues were recognized. Some of them are specific to the Croatian language.

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Write on the Edge: Using a Chemistry Corpus to Develop Academic Writing Skills Resources for Undergraduate Chemists

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Many undergraduate students find the production of an extended piece of academic writing challenging (Ganobcsik-Williams, 2006). This challenge is more acute in the sciences where production of extended texts is often infrequent throughout undergraduate studies. This presentation will report the development of a new English for Academic Purposes (EAP) workshop and associated resources for third year undergraduate chemists to support their dissertation module. The workshop and resources are designed to utilise a searchable database of student texts (a corpus) developed as part of the FOCUS project at Durham University (Bruce & Rees, 2013). This novel use of Data-Driven Learning (DDL), common in second language pedagogy (Johns, 1991), transfers well to the chemistry classroom as the processes of research and discovery (of words rather than chemicals) involved in DDL parallel similar processes in chemistry research. Our workshop and online consolidation activities have been positively evaluated by both staff and our current cohort of students. The project is currently being rolled out across other departments at Durham as well as the corpus tool being utilised at other UK HEIs. This corpus-based approach to academic writing in chemistry offers a unique perspective on the interplay between language and scientific literacy.

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Chemistry Teachers` Pedagogical Scientific Language Knowledge

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Learning of scientific language and its proper use in science classes is one of the main aims of science teaching. However, it is widely known that students have different problems understanding and using scientific language. Furthermore, science teachers are a key factor in promoting changes in science lessons. Their actions in the classroom are influenced by their personal knowledge and beliefs. Therefore the aim of the present case study is to develop an instrument which can portray science teachers` pedagogical scientific language knowledge. Pedagogical scientific language knowledge (PSLK) is defined as teachers` pedagogical language knowledge with the focus on scientific language of chemistry. Pedagogical language knowledge is defined as a „…knowledge of language directly related to disciplinary teaching and learning and situated in the particular (und multiple) contexts in which teaching and learning take place" (Bunch, 2013, p.307). For the present study, the idea and the definition of pedagogical content knowledge (PCK) by Loughran, Berry and Mulhall (2006) was used for the presentation of PSLK. The study explores the development instruments similar to CoRe (Content Representation) for teaching and learning scientific language in science classes. The study is based on open interviews with 11 science teachers with regard to their knowledge concerning scientific language in the classroom. The results show that it is possible to develop a tool examining science teachers` PSLK. Furthermore, the study reveals that levels of teacher PSLK tend to be quite low and in many cases represents a naïve view of teaching of scientific language. Science teachers generally know only a few methods for teaching scientific language. Most of them do not really pay attention to it in detail during their lessons. The results will be presented and discussed using the CoRe format of expression. Recommendations for pre- and in-service science teacher training will also be made.

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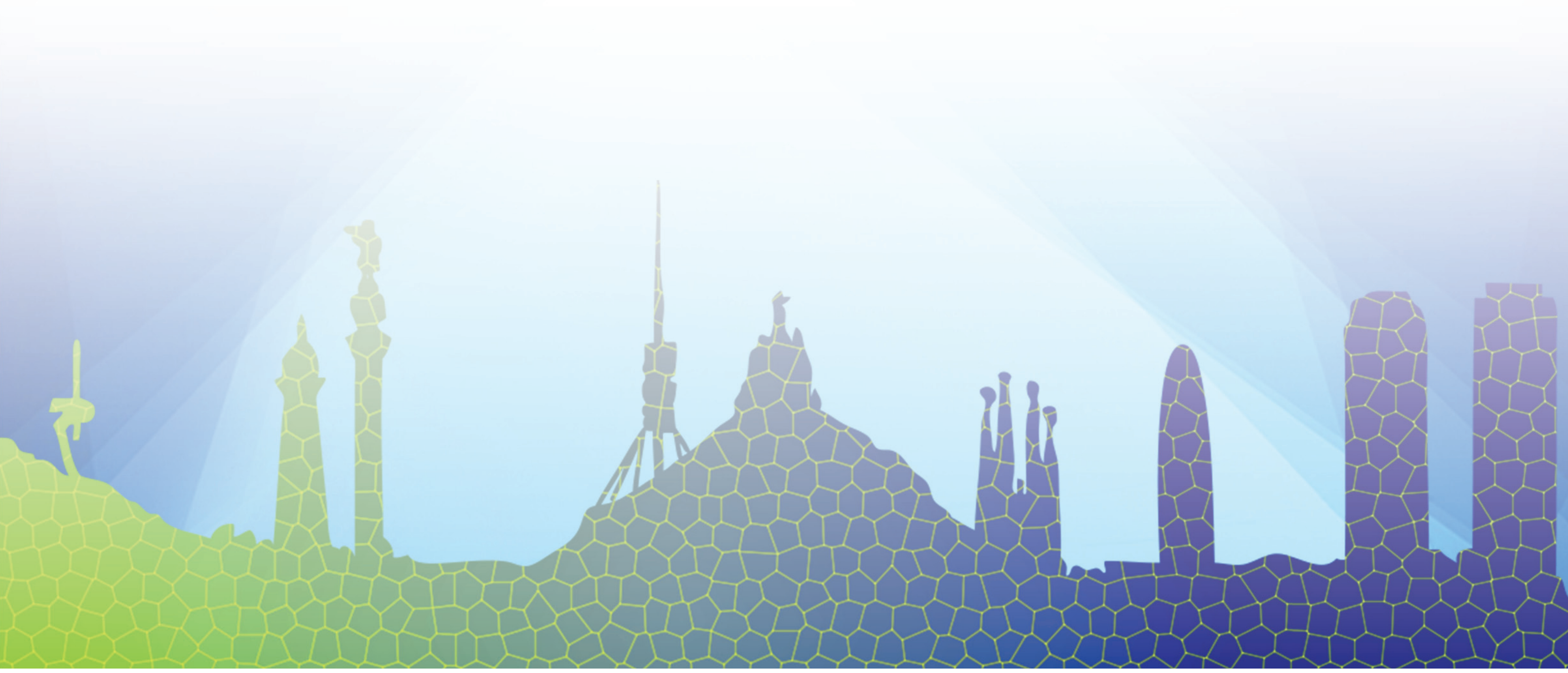

Oral *Communications*

Investigating and mitigating chemistry students' illusions of competence

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We have demonstrated that low performing general chemistry students suffer from illusory competence—they are substantially miscalibrated from their actual standing on course assessments. This miscalibration phenomenon also appears to persist across a semester, despite repeated feedback. However, exam self-assessment appears to abate students' illusions of competence. Briefly, students addressed why a specific exam response did not receive full credit, provided responses that would have received full credit, and reflected upon learning/studying issues that resulted in receiving less than full credit. Using a combination of graphical analyses and hierarchical linear modeling, we confirm that self-assessments help students to become more calibrated to their performance on subsequent exams.

Using reflections to promote metacognitive awareness in students' conceptual understanding and problem solving abilities in chemistry

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Metacognition has been defined as thinking about one's thinking[1]. It is the awareness of and reflection upon one's own cognitive process, which can induce self-regulation and conscious coordination of learning tasks. Since the mid-1970's, metacognition has been studied extensively with intense focus on metacognitive knowledge, metacognitive monitoring, and metacognitive control. Metacognitive monitoring is an individual's ability to assess their state of cognitive activity and regulate their cognitive activity[2]. The central focus of this study looked at students' metacognitive monitoring related to their conceptual understanding of chemistry topics and their problem solving abilities related to these topics. This study took place during a second semester general chemistry course at the undergraduate level.

Throughout the semester students completed ten reflections, roughly every other week. One component of these reflections asked students to rate their conceptual understanding of various chemistry topics as well as their ability to solve problems related to these concepts. Students rated each topic three times throughout the semester: after each chapter, after each hourly exam, and before the final exam. This study will present an analysis of how students' ratings related to both exam performance and monitoring abilities throughout the semester. Findings showed that using ratings as a form of reflection promoted growth in students' ability to monitor their conceptual and problem solving of chemistry concepts as well as increase their overall understanding of these topics.

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Feedback in blended learning laboratory classes as a way to improve success of student teachers

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The impact of feedback on the learning process is well known. Therefore some options for giving feedback have already been implemented in learning management systems (LMS), but there are many limits and restrictions. Automatically generated criteria-based feedback is one way to redress these limitations and to foster students more goal-orientated.

Blended Learning, as the support of traditional presence-based teaching by electronical study opportunities, is often used as a chance to support students more individually and goal-orientated. We have already achieved sustained success by using this concept in our laboratory classes for student teachers in chemistry. Students can prepare the subject matters for the next lesson completely at home, and therefore can use the time in the laboratory more effectively. To ensure a good preparation at home, students need an expressive feedback. The strong impact of feedback has also been proved by Hattie (Hattie and Timperley, 2007). This raises the question how can feedback be implemented in Blended Learning for fostering students' success? Which possibilities for giving feedback are already established and where are their limits?

Until now, LMS merely offer limited possibilities for giving feedback. Most LMS can only report the correctness of a given answer or the reached total score in a test. In the majority of cases, features such as elaborated feedback (Narciss, 2012a; 2012b), which aim at delivering further information, e.g., about common mistakes or reoccurring errors, do not exist. With regard to a final examination a more detailed feedback informing about personal strengths and weaknesses would be desirable.

To reduce this lack in giving feedback, we developed an own software solution. The software analyzes all students' test data in a course on the basis of predefined criteria. A criterion in this context means an assembly of exercises within the LMS dealing with the same competence or learning objective. By performing a criteria-based analysis of the test results, the software gathers all necessary data to generate a feedback text, which is send to our students by email. This software puts ourselves in a position to deliver a more expressive feedback, which not only addresses the current performance level, but also names the main goals for reaching an improvement and; in addition, it gives some suggestions for achieving these goals. For the first time, we are able to provide a feedback to our students, which seems to be effective according to Hattie (Hattie and Gan, 2011; Hattie and Timperley, 2009). This new kind of feedback outperforms the possibilities for current feedback options in LMS by far. As a consequence, our students are better prepared for the laboratory sessions, while the number of occurring mistakes is decreasing.

Automatically generated criteria-based feedback establishes a new fascinating field of research. On the one hand, the models for assessing students' learning performance utilized by the software have to be improved. On the other hand, there is a great lack of information about the impact of this kind of feedback on students and their learning process. There is a lot of work to do in both topics. We would like to present our experiences in this new field of research and how this impacted our student teachers in the laboratory classes.

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Theater in chemistry education: analysis of an experience at the University of Valencia

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Abstract

"Theater is pure Chemistry; Chemistry is pure Theater", a project developed at the University of Valencia since 2008 with undergraduate students, has become an extremely valuable tool to motivate them. The results and the usefulness of such an educational initiative, including points of view of both teachers and students, are shown and analysed.

It is well known that the use of drama, guided by reflective science teachers, may provide empowering learning environments for students and promote positive attitudes toward science [1]. However, as Carl Djerassi pointed out, "chemistry is probably the scientific discipline that is least widely represented in fiction or in the theatre compared to medicine or even physics" [2].

In this contribution, we present an eight-year-old project [3] carried out at the Faculty of Chemistry of the University of Valencia (UV) in which undergraduate students write and perform a play, with two main objectives: first, they must analyse basic chemical concepts in depth, in order to find that metaphor or unexpected situation to approach them in a different but amusing way. And second, they have to face the challenge of increasing the motivation of a group of youngsters (16-18 years old) with regard to our discipline [4].

Every year, two or three performances are organized at the UV for secondary schools. Between 200 and 300 students, together with their chemistry teachers, attend every performance.

In order to give an insight into the usefulness and the impact of such a project and determine whether the objectives are accomplished or not, we designed two surveys: a first questionnaire was answered by the chemistry teachers and a second one by the undergraduate students who took part as authors and actors/actresses. From the results obtained, it is concluded that both groups strongly recommend the activity. Teachers emphasize that the performance clearly increases the motivation of their students, who realize how much they have already learned, since they are able to understand those jokes involving chemical concepts. On the other hand, the undergraduate students emphasize that the project stimulates their creativity, their communication skills, and the discovery of the chemical phenomena in everyday life.

The project was awarded with the Educational Quality and Innovation Award of the Board of Trustees of the UV in 2010.

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The investigation of pre-service elementary science teachers' interest in acid-base

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Hidi (2006) explained that "interest to be a unique motivational variable, as well as a psychological state that occurs during interactions between persons and their objects of interest, and is characterized by increased attention, concentration and affect (p.70)." The students are eager to learn and curious about topics of their interest. They ask questions and seek answers regarding topics of their interest (Renninger and Hidi, 2002). They are not being bored while they investigate topics interesting to them (Renninger, 2000). Therefore, interest in topics is one of the factors affecting learning. In the literature, there are studies about interest in science (chemistry and biology) (Ilhan, Yildirim and Sadi-Yilmaz, 2012; Trumper, 2006). However, there is not much research on topics of science such as acid and base.

The aim of the study was to investigate the level of pre-service elementary science teachers' interest in acid-base according to various variables (gender, grade, graduated high school type and score of "General Chemistry II" course). Survey method was used in the research. The participants of the study were 982 pre-service elementary science teachers who enrolled in eight different state university during 2014-2015 academic year. Data in this study were collected by using Acid-Base Interest Scale (ABIS) developed by Cicek (2015)**.** ABIS consists of 26 items and three dimensions ("personal interest", "interest to theoretical knowledge" and "Interest related to daily life"). Reliability coefficient (Cronbach's Alpha) for ABIS was found as 0.894. The factor structure of ABIS was determined by confirmatory factor analysis. The collected data were analyzed by using descriptive and inferential statistics.

According to the findings, mean of the items of the ABIS ranged from 3.184 to 4.053. For example, Item 9: Acidic foods and drinks how they harm our body (the teeth, stomach and so on (M=4,053). Item 23: Properties of metals (hydrogen gas is produced If a metal reacts with an acid) (M=3.184).

According to findings, female pre-service teachers' (M=95.05) interest to acid-base were significantly higher than males (M= 91.22), t(980)=3.54, p<0.05). In terms of grade level, it was found that 2nd grade pre-service teachers' interest in acid-base was significantly higher than 4th grade, $F(3, 978)=3.250$, $p<0.05$. In terms of graduated high school type, findings indicated that there were no significant difference in pre-service teachers' interest in acid-base, $F(2, 979)=1.953$, $p>0.05$. In terms of score of "General Chemistry II" course, findings indicated that there were no significant difference in pre-service teacher' interest in acid-base $F(3,670)=1.857$, $p>0.05$.

According to the results of the study, it can be seen that pre-service teacher' interest in acid-base vary in terms of gender and grade level. To develop interest in chemistry, it is significant to know that the level of pre-service teacher' interest in subject of chemistry. Result of the study can be used in the design of the content of activity and books.

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ORAL COMMUNICATIONS
OC 06

Progress in primary school children's understandings of dissolving: A cross-age qualitative survey

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Research on when and how students develop an understanding of various science concepts is essential for designing and implementing chemical courses. This study sought to examine young children's conceptual progression patterns for the concept of dissolving. Dissolving provides an appropriate context to examine children's understandings of the particulate nature of materials, as it is a usefu illustration of the transformation of matter into invisible particles, while children are familiar with the phenomenon as they have everyday experiences of it. By adopting a structured interview protocol from Nakhleh and Samarapungavan (1999) and using as a sample 108 children of four different year-groups (*n* = 27 5-year-olds, *n* = 27 7-year-olds, *n* = 27 9-year-olds, *n* = 27 11-year-olds) in the United Kingdom, this study provides a detailed description of the progress of children's understandings of the process of dissolving. The findings suggest that 5-year-olds understand the process in terms of the changes happening to sugar. However, as they grow up there is a gradual progress in their understanding the process as a whole and attending to changes happening to both substances. Furthermore, children after the age of 9 start using some chemical terms to describe the phenomenon as dissolving, molecules etc. These findings suggest multiple levels of understanding the process of dissolving and that each child attaches different meanings to the phenomenon. The findings of this study could provide educators with the means to design and implement teaching interventions that will be in harmony with what children are capable of grasping in each year-group

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The Quest to Design Effective Visualizations

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Dynamic visualizations are typically designed to address key structural aspects of reactions, as well as the mechanism that takes place. Unfortunately, the complexity of animations can make them challenging for students to interpret, and the nature of the viewing process, in which students try to absorb as much detail as they can, makes long term retention challenging. In order to construct a visualization scenario that motivates students to consider the accuracy of the depiction, I have constructed animations in conflict with each other. In the study, students were shown a VisChem animation, known for its complexity and accurate depiction of the electron cloud transfer in a simple redox reaction between solid copper metal and aqueous silver nitrate. In contrast, students were also shown an animation of the same event that wrongly suggested a physical exchange of the silver ion partnered with nitrate for a copper ion as the mechanism. The students were asked to critique the animations as they were supported or refuted by experimental evidence shown through video. The findings of this work indicated that less than half of the students revised their initial explanations to adopt an electron transfer model. With these disappointing findings in tow, I set out to construct a new animation of the electron transfer model by enlisting chemistry faculty to review the VisChem animation and then consider how they would change this model to more effectively teach electron transfer. This presentation will examine how interviews and picture construction tasks with experts, representing a variety of chemistry disciplines, affected their design suggestions and led to the development of new visualizations.

Graphical representations in electrochemistry – do they relieve some difficulties?

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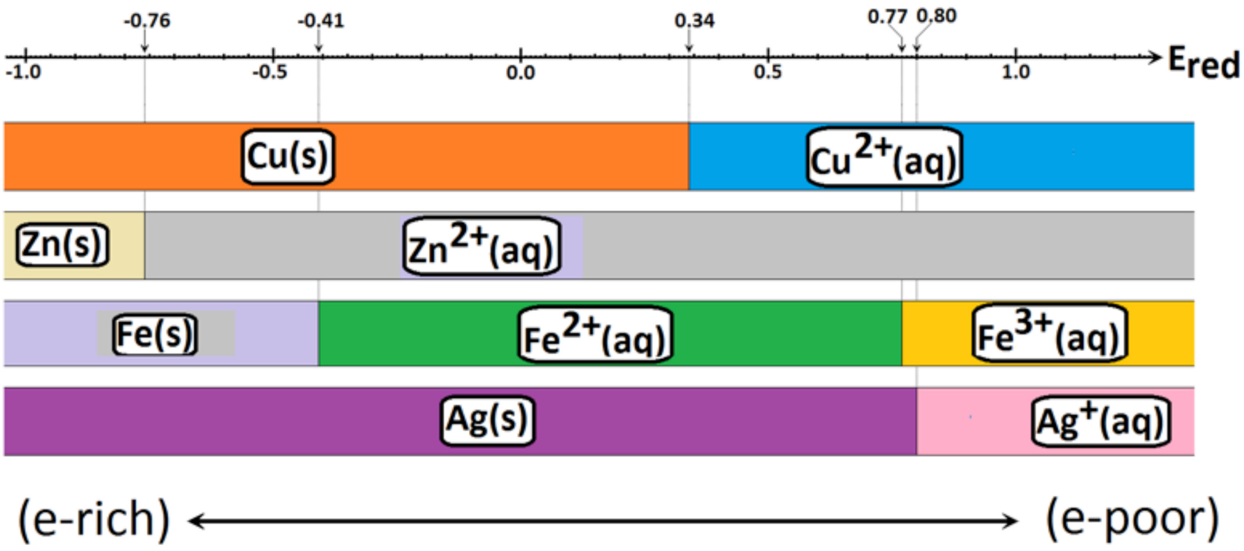
Several discussions with university students and teacher in practice reveal that the electrochemical series is a difficult area of chemistry sometimes reaching mythical levels (Eriksson & Kaufmann). We postulate that this to a large degree is due to the abstract and limited information in reduction potential tables or similar abstract and compact tabulations meant to show some meaning onto electrochemistry. We propose that the electrochemical series should be presented with a graphical representation of the different chemical subsystems showing most every important species included in the reactions instead of only the reduced form of each half cell.



It is easy to see that:

- Some specie that need electron rich environment cannot simultaneously exist as some other species that require electron poor environment. A reaction will occur..
- Cu(s) can coexist with Fe(s).
- Cu^{2+}(aq) cannot coexist with either Zn(s) or Fe(s).
- Cu(s) can be oxidized by Fe^{3+}(aq).
- Ag^{+}(aq) and Zn(s) do differ approximately 1,56 V in reduction potential.

Ref.

Eriksson & Kauffman, in manuscript to be submitted to chemical education, 2016.

Finnish subject teachers' perceptions of art integration in chemistry education

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Meaningful chemistry education could benefit from arts integration at least for the three following reasons: Arts integration can provide a natural sense of surprise and lead to commitment and enthusiasm as in the case where students were asked to create art about alkali metals (Araújo, Morais & Paiva, 2015). Arts make use of personal experiences, which could support e.g. personalization (Hodson, 2009) of science. Integrating arts emphasizes sensory experiences and could support learning of science as in the approach of embodied cognition, which supposes that thought processes are not limited to the brain (Close & Scherr, 2015)

In order to develop feasible interdisciplinary pedagogical models, Finnish science teachers' perceptions of integrating arts into their teaching were explored in an e-survey. Initial results from a section, based on previous suggestions in the domain of art integration (Reif & Grant, 2010), are reported. 23 participants taught chemistry as a main and 40 as a secondary subject. School levels ranged from K-7 to K-18.

The initial results obtained from descriptive statistical analysis indicate that arts integration in science education is not extensive. Most of the teachers (51%) didn't report to integrate arts in their class. However, an active minority (11%) integrates arts as contexts or art activities more than 3 times per teaching unit. The aspects of contextualization and making art were further clarified by content analysis:

- *Contextualization* is set up with art pieces or fields of art to guide attention in areas where science and art overlap such as light, colors, waves, patterns and forms. Additionally, overarching contexts can be used to make indirect connections. E.g. the idea of the colorfulness of autumn were connected as point-by-point drawings and molecular events.
- *Making art* can be used to actively work with science concepts or to do exploration related to inquiry. The most frequent activities reported by teachers were painting and drawing. E.g. Students drawings of half full containers can be used to initiate discussions.

The two aspects above imply that 1) the contexts in the arts integration are related to sensory experiences suggesting a connection to the approach of embodied cognition and that 2) making art can be related to inquiry, which could be explained by similarities in the practices as both can begin with an open exploration of the topic and both aim to representation and communication as the outcome of the activity.

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The investigation of pre-service teachers' self-efficacy perceptions on acid-base topic

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It is known that the perceived self-efficacy is not an individual's ability to do a task but it's his personal judgment and beliefs concerned with completing that task successfully or not (Bandura, 1977; Bong, 1995). Perceived self-efficacy may change up to individuals, societies and areas and may affect the communication of individuals with their environment (Bandura, 1997). As teachers having high self-efficacy in their profession ensure them to be successful and attentive in their profession and enthusiastic and patient in their classes, the performance of the students are affected positively by this situation (Aydın, 2008). It's believed that determining the teachers' perception of self-efficacy regarding science teaching related to subjects in classes is important. Studies about perceived self-efficacy related to a particular chemistry topic are not found in the literature. The aim of this study is to investigate the level of pre-service science teachers' self-efficacy perceptions on acid-base topic in terms of various variables (gender, grade, the type of high schools graduated and achievement at General Chemistry II lesson).

Survey method was used. The sample of the study consists of 982 pre-service science teachers in department of science education at eight different state universities. In the study, ''Acid-Base Self-Efficacy Perception Scale (ABSPS)'' developed by Cicek (2015) was used as the data collection tool. ABSPS, a five-point likert type, consists of two dimensions (''Relating to daily life'', "Knowledge on topic and scientific explanation") and 14 items. For the collected data in the study, the reliability coefficient Cronbach's Alpha was 0.823. The dimensions of ABSPS were determined by confirmatory factor analysis. Data were analyzed by using descriptive statistics, independent samples t-test and one-way analysis of variance (ANOVA).

According to the findings, mean of the items at ABSPS ranged from 3.281 to 4.142. Item 7: While using acidic or basic materials (bleach, drain opener and etc.), I can take precautions in terms of health and safety (M=4.142). Item 11: I feel myself efficient in scientific discussions about acids and bases. (M=3.281). When analyzed in terms of gender, levels of self-efficacy perceptions on acid-base topic of the female pre-service teachers (M=53.50) were significantly higher than the male pre-service teachers (M= 51.16), $t(980)=4.36, p<0.05$). When analyzed in terms of grade, it was found that 2nd and 3th grade pre-service teachers' self-efficacy perceptions on acid-base topic was significantly higher than 1st grade pre-service teachers' self-efficacy perceptions on acid-base topic, $F(3,978) = 6.788, p<0,05$. Results indicated that there were no significant differences in pre-service teachers' self-efficacy perceptions on acid-base topic in terms of graduated high school type, $F(2,979)=0.426, p>0,05$. And finally in terms of achievement of "General Chemistry II" course, results indicated that level of pre-service teachers' self-efficacy perceptions on acid-base topic who have high scores in "General Chemistry II" course, were significantly higher than the pre-service teachers who have lower scores in this course, $F(3,670)=4.064, p<0.05$.

The results show that pre-service teachers' self-efficacy perceptions on acid-base topic vary in terms of gender, grade and "General Chemistry II" course scores. Studies which are examining self-efficacy related to Chemistry topics would contribute to the literature in order to develop pre-service teachers' self-efficacy perception related to chemistry topics.

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Measuring aspects of students' motivation towards learning Chemistry

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The partial results of a research inspecting the motivational orientation of secondary school students towards education of chemistry are presented in the communication. More than 2 000 students have been administered the Motivated Strategies for Learning Questionnaire (MSLQ) originally created by Pintrich et al. (1991, 1993) for assessing students' motivational orientations and their use of different learning strategies for college courses. In this study, we used only motivation section of Pintrich's tool to assess several aspects of Slovak students' self-perceived motivational orientation related to Chemistry as an educational subject. The motivation section of the questionnaire includes 31 items divided into 6 subscales each measuring the specific dimension of motivation. The subscales are as follows: (i) *Intrinsic Goal Orientation*, (ii) *Extrinsic Goal Orientation*, (iii) *Task Value* as value components, (iv) *Control of Learning Beliefs*, (v) *Self-Efficacy for Learning and Performance* as expectancy components and (vi) *Test Anxiety* as affective component.

Four research questions were addressed by the study: (1) What is the level of student's self-perceived motivation towards Chemistry as a subject? (2) Can the factors influencing this level be identified? (3) Can students be layered (classified) according to the level of their motivational orientation considering different dimensions of motivation? (4) Is there a relation between student's self-perceived motivation and the final grades they achieve in Chemistry?

As the process of data collecting and data treating is still running, in this communication we provide the partial findings only resulting from the first 754 administered respondents. Several statistical methods where used to process the data starting with descriptive and frequency analyses of the responses, continuing with comparative analyses (ANOVA), a cluster analysis and correlation analyses. In order to be sure about the satisfactory level of reliability and validity of the data, the Cronbach's alpha coefficient for each subscale was computed to uncover the internal consistency within the subscale and confirmatory factor analysis (CFA) was performed considering several potential structure models of the dimensions measured by the research tool.

In comparative analyses (ANOVA) several factors potentially generating statistically significant differences in motivational orientation were considered, for instance, gender, a specific school and a class (year of study) attended by a student. The preliminary results indicate gender differences in the most subscales, except *Extrinsic Goal Orientation*. Students of different class seem to be significantly differently motivated mainly in *Intrinsic Goal Orientation*, *Task Value* and *Control of Learning Beliefs*. Almost no relation was found between the level motivation and an attended school. The hierarchical cluster analysis (using Ward's method of agglomerative clustering) suggests that students can be layered into 3 reasonable clusters according to their motivational orientation. We can also intimate that in some cases the final grade achieved by a student can be used to predict the level of his/her motivational orientation towards learning Chemistry.

In spite of having some minor empirical evidence about the specific contributions to the whole concept of motivation for learning Chemistry, farther research is needed to understand all relations in order to find educational ways of influencing motivation in a positive manner.

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'On-line Continuous Assessment'–What do Students think?

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Abstract

Engaging first year University science students in all aspects of chemistry can be a challenging task and many different forms of support have been made available throughout the years. This paper discusses the student engagement and learning from on-line tutorials and continuous assessment assignments.

With 240 first year undergraduate students taking modules in Chemistry as part of their science programmes, creating a supportive and engaging environment is important to enable the students to make the transition from second level learning to third level understanding. As the first year cohort is a very heterogeneous grouping, in terms of their prior knowledge and experiences with chemistry, their scientific interests, their motivation and engagment, it is necessary to provide a range of supports to meet their diverse needs (Lovatt & Finlayson, 2013).

In the author's university, the first year students attend 3 lectures per week and a 3 hr laboratory session, complementing the lecture material. As well as face-to face lectures and on-line supplementary material, the use of on-line continous assessment excercises has been developed to both support and encourage students to engage with the course content. These on-line continuous assessment exercises are part of a commercial support provided by the publishers of the recommended text book. Three modes of continuous assessment have been used: 'Practice problems'; 'Homework assignments' and 'Learnsmart'. While the former two modes are quite similar, 'Learnsmart' is an 'adaptive learning program that helps students succeed by providing a personalized learning path that's based on their responses to questions.'(McGraw Hill).

This paper will explore the use and benefit of this technology in terms of encouraging student engagement and learning. Through analysis of student completed questionnaires and feedback, the benefits of different modes of continuous assessment will be determined. The relationship between the continuous assessment exercises and the final examination questions will be determined, both in relation to the content of the questions and also the level of difficulty of the questions, the time required to answer the questions and the level of understanding required. Likewise consideration will be given to the aims of the lecturer when selecting such on-line continuous assessments compared to the students preception of these exercises. From a thorough analysis of this data, recommendations will be made on the appropriateness of particular modes of continuous assessment for learning and particularly the use of commercial support systems to support learning.

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The magic of the periododic table: from illusion to game

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For the last two years we have undergone a project that involves the use of magic and illusionism techniques, mainly based on mathematical principles, with the purpose of entertaining but also with the goal of increasing the public understanding of core chemistry values, in this case a basic knowledge of the Periodic Table of the Elements.

This team has developed a varied activity, from hands-on workshops, interactive shows, and demonstrative performances, from a few number of very young students, to a 300-people cloud of attendants in a theater. This show won the Mention of Honor at the ***Ciencia en Acción*** contest in 2014, while it has been presented at several cities in Spain and in Europe: Nancy (Science&You), London (Science on Stage), ... International activities have been held also in Brussels (Researchers' Night 10th Anniversary, Sept 2015), and are expected to be shown in Manchester (Science in the City) and Varsaw (Science Piknik) along 2016.

Overall reception of the Magic of Chemistry has been very strong, because it combines the secrets of mathemagic and mentalism with the amazing outcomes of less well-known chemical experiments. Our team is willing to increase Public Awareness of Science, so we try to make activities enticing and attractive, but is also pushing for Public Understanding of Science, so depending on context we explain the intrinsic and secrets of experiments and games.

Our hand-on and demonstrative shows are complemented in two ways: first, by an active Internet activity, like the "Which element are you" game-contest developed from February 2016, where we map the calendar year to 3 periodic tables containing 122 elements each, and also to 7 full 52-card poker packs. Furthermore, we have coded mobile apps for this activity and for other games, based on activities adapted from classical games to the Periodic Table.

Moreover, this involvement in the Periodic Table has been recorded in video clips stored in our website, readily available, and used but the forthcoming MOOC (Massive Open Online Course) in Spanish "Magia, Ciencia y Secretos Confesables".

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[2] Project hashtag: #lamtp (for twitter, facebook and other Social Networks communication)
[3] Info from @c4dudg: http://c4d.udg.edu
[4] Partially funded by FECyT Project FCT-14-9228, "From the Magic of Science to the Science of Magic"

Activity-Based Chemistry Teaching Materials at Compulsory Secondary School: results of classroom implementation

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Abstract: Analysis of key content of activity-based chemistry teaching materials of the curricular project for all students (12-15 years old) are provided. There are also provided the conclusions and results of the post-implementation teacher questionnaires analyzed along with the direct observation of the teachers and the class.

Since the beginning of science, knowledge has been produced by groups of experts/specialists. Nowadays, new educational aims (teaching scientific competence ***to everyone, not just to experts/specialists***) present significant challenges. The new teaching should bring about genuine ***chemical activity*** at basic educational levels as a condition for students to acquire ***chemical thinking***. In order to move forward towards new teaching proposals, we must identify the ***genuine questions*** that generate 'chemical criteria' and we should focus on them for teaching. Which are the genuine questions, not reducible to those of other disciplines, posed by chemistry?

Our proposal is integrated in a curricular project 'Scientific Thinking Competences. Science 12 to 15. The aim of this project is to promote genuine scientific activity as a modelling process with a scientific multidisciplinary view. It exemplifies how to design school science as a world-modelling activity and how to integrate ***context-stories*** that lead to the construction of science ideas and models.

This communication will present the key aspects of the chemistry approach in this project. Students' experience of the interaction between materials and substances is essential, as without it, school chemistry would consist of just words without any practical meaning. A modeling process (doing, thinking and communicating) transforms these selected phenomena into examples of chemical change or weaker interactions.

Our research is focused on the design and results of implementation of the chemistry module of the project. Results of the implementation of this module, the reflections about teachers', and students' achievements will be presented. The classroom performance of teacher is also analyzed. Conclusions show the need of helping teachers with further training activities, to implement teaching materials in classroom in a way to enhance development of scientific competencies in pupils within the field of chemistry.

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Investigating and Evaluating Outreach and Public Engagement Programmes, to establish whether they can Improve/Enhance Scientific Literacy

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STEM research is high on the agenda of policy makers globally, particularly within Ireland and the European Union. This is mainly due to the influence STEM research can have on the economy, and the way we live our lives daily. With STEM research so high on the agenda, the responsibility on scientific researchers to communicate research outcomes and impacts to the public is also increasing. The public play an important role in STEM research–paying the taxes which fund same. They are also a potential consumer base for applied research commercialisation. It has been stated that one way of making science accessible to the public and providing opportunities to engage with it, is through public engagement events where scientists are in a position to interact with public audiences (Besley & Tanner, 2011). An informed and engaged public is one that understands the role of science, can judge between competing priorities and arguments, encourages young people to take STEM subjects, and feels that is has the appropriate level of engagement with, and influence upon, the researchers (SFI, 2015). However, researchers often presume a public deficit when it comes to knowledge, attitudes or trust (Bauer, Allum & Miller, 2007), and this tends to inform how they will interact with the public. The International Council for Science (ICSU) strategic plan for 2012 – 2017 states that they want to "increase visibility and outreach, making maximum use of website and other social networking and multi-media tools" (p.10). The premise of an informed and engaged public presumes a degree of scientific literacy among the population, particularly as it has become an educational goal of most countries. Many educationalists (Bybee 1991; Millar & Osborne 1998) describe scientific literacy as the main purpose of science education. Among many practitioners, curriculum developers and policy makers, there is often an assumption that if an individual knows enough Science that they will be able to apply it in life situations (Bybee and McCrae 2011). Driver, Newton and Osborne (2000) state that:

"the claim 'to know' science is a statement that one knows not only what a phenomenon is, but also how it relates to other events, why it is important and how this particular view of the world came to be. Know any of these aspects in isolation misses the point." (p.297)

This study seeks to examine the relationship between these science communication/outreach activities and scientific literacy. When looking at the effectiveness of using science communication and outreach to engage different audiences, a number of issues emerge. With many conceptions and values attributed to scientific literacy one must consider which stance is appropriate. To date the work draws from established areas of research, such as Nature of Science (NoS), Argumentation and Inquiry-Based Science Education (IBSE), comprising elements of scientific literacy. Each of these areas comes with a significant body of literature, although the precise definition of each can be contentious. Further work will be carried out to establish the key elements of scientific literacy, with the overall goal being, to develop a toolkit for use in public outreach and communication activities to enhance the development of scientific literacy among a target population.

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Longitudinal study of students` conceptual structures concerning chemical bonding from middle school to upper secondary school

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Abstract

The aim of the study is to follow up the evolution of conceptual structures relating to chemical bonding from middle school to upper secondary school. At the middle school students have been teached by the novel way, which emphasis the coulombic interaction as the basis of chemical bonding. The study highlight detailed insight of the mechanism, how the octet framework prevents meaningful learning.

Introduction

Octet framework is a common alternative framework which prevents the meaningful learning and coherent construction of conceptual structures relating to chemical bonding (Taber 1998). We have developed a novel way to teach chemical bonding which emphasis coulombic interaction as the common basis of all types of chemical bonds (Joki et al. 2015). At this study we have followed up how the conceptual structures evolves when students continues their studies at the upper secondary school. Unfortunately it is very common that the octet rule is a central concept in the teaching also in upper secondary schools (Bergqvist et al 2016).

Methods

Eight high achievers students participated individually to the clinical interview at the end of the middle school. They have studied chemistry with the novel way to teach and learn chemical bonding, which emphasis coulombic interaction as the basic point of all kind of chemical bonding types. (Joki et al. 2015.) All eight students were involved to the individual follow up interview during the first school year at the upper secondary school. Eight students continued their studies at four different upper secondary schools and they have had five different teachers at chemistry during the first school year at the upper secondary school.

Findings

Except for one, all the interviewees had adopted more or less the octet framework during the first year at the upper secondary school. The student who did not bring out octet framework was the same, whose conceptual structures were most coherent and most covering at the first interview session.

The students have studied at the middle school chemical bonding in the novel way in which an attempt was made to avoid octet framework and instead coulombic interaction was emphasised. Now they have learned octet framework afterwards and it appears to be a competing conceptual structure. Study reveals in detail that the octet rule competes especially with the deeper understanding of the electronic structure and how the electronegativity relates nuclear charge and the energy levels of the electronic structure.

The student who has explained ionic lattice structure properly at the end of the middle school, has developed molecular ontology regarding ionic structures during the upper secondary school studies. On the basis of the interview it seems, that the pupil during the studying weak intermolecular interactions and polarity has concluded that ionic structures consist of extremely polar molecules.

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Chemical names and formulas: french students' difficulties

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Studying chemistry includes learning the language of chemistry (names, formulas, symbols, chemical equations) (Laszlo, 2011; Taber, 2009). Learning this language should be done by understanding the concepts used by the chemist (Talanquer, 2011). As in mathematics education (Duval, 2006), using several semiotic systems poses numerous difficulties to students (Taskin & Bernholt, 2014). This difficulty is not always taken into account in chemistry teaching (Kaya & Erduran, 2013) and the teachers may not be aware of it (Mzoughi-Khadhraoui & Dumon, 2012). Thus, we conducted an investigation to find out how French students understand and use names (of chemical species and of common mixtures) and chemical formulas: do they make a distinction between scientific names and usual names in order to differentiate between chemical species and mixtures? To what extent do they master chemical formulas? We administered a paper and pencil test composed of an open-ended question and two multiple choice questions to students (N=603) who have been learning chemistry for 2 years (age 14) and others for up to 7 years (age 19, first year university). In the first question the students are asked to classify names from a list including usual names and scientific names. In question 2, three pairs of chemical formulas (H2O and H2O2; O and O2; CH4 and C2H8) are given; for each pair the students have to say whether the formulas correspond to the same molecule. In question 3, a chemical equation including O instead of O2 and another one H4O2 instead of H2O are proposed with two correct chemical equations, the students are asked which ones are wrong. A great number of students (35%) do not answer the first question. The students' classification proposals rely mainly on two criteria: the state of matter (gas, liquid and solid) (17%) and the opposition between macroscopic and microscopic levels (24%). Thus the scientific name opposed to a common name does not seem to be a relevant tool used by the students (7%) to classify chemical species and mixtures. The students struggle to decode a chemical formula out of the context of a chemical equation (37% answer que

Effect of course redesign on student learning in an introductory chemistry course

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Recently there has been a substantial focus on the implementation of online learning in various disciplines. In the United States, the National Center for Academic Transformation (NCAT) offers several models for course redesign. In the replacement model, one or more lectures are replaced with online learning.

The presentation will show (a) how the pass/fail dynamics was affected, (b) how the course was standardized using redesign for the entire cohort and (c) how this effort resulted in cost savings for students. Additionally, student and faculty perceptions of learning improvement and increase in final exam scores over several semesters will also be presented. Lastly, the presentation will also include an independent external evaluation by an assessment expert to ensure that there is no bias in the research design.

Analysis of how chemical knowledge is transferred in context-based education: students' difficulties and ways of reasoning

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Scientific literacy is considered a key competence for all citizens and it is related to the ability of applying science to every-day situations. Context-based education has been successful in improving students interest in science but more research is needed to clarify if it fosters students' ability to apply what has been learnt in one context to a new one. In many social sciences this ability is called transfer (Gilbert et al., 2011). A three-attribute model for transfer in chemical education has been characterised to distinguish between near and far transfer and to design assignments and assess students degree of success (Sasson & Dori, 2015). However, this model has not addressed the specific features of context-based projects that may be involved in transfer development.

This research has two objectives: 1) To Analyze students difficulties when they transfer knowledge using chemical ideas and language to explain a phenomena; 2) To identify the way of reasoning that students use to transfer chemical knowledge orally.

The methods used in this research are: 1) Written assignments that were answered in different moments of the school year; 2) Think-aloud interviews to analyse how students solve a problem. In both cases it was required to apply chemical knowledge in an everyday situation that was not faced earlier. The sample is a group of 15-year-old students that have followed a context-based course for learning the essential chemical theories from compulsory science curriculum in Spain.

On the one hand, many students' difficulties have been identified: persistence of chemical misconceptions, partial activation of the theoretical model, activation of inappropriate science ideas, lack of analogical reasoning between the new context and any of the learning contexts and lack of coherence in the linguistic patterns of the explanation.

On the other hand, two strategies that seem to be involved in the transfer capability of students have been discussed. Analogical reasoning is a common strategy that is carried out by remembering key moments of the learning process, such as contexts, experiments, videos or group discussions. In some cases the analogue helped the student in recognising the key ideas that had to be transferred. Activation of abstract theoretical ideas also lead to acceptable transfers although in some cases students' mental models where "inert knowledge" because they could only be recalled but no applied.

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Parents and students cooperatively experiencing chemistry

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Family and parents play a crucial role in developing of students' interest about special topics and school subjects. Thus, it is important to know and understand parents` and near family`s interest, their attitudes and beliefs towards chemistry but also their conservation of value (Gans, 2008). Starting from here and aiming to support student even more, it is necessary to take a closer look to the students` families and their parents` interests, motivation and attitudes. Additionally, the awareness about the influence of once migration background is not only getting bigger in Germany but also all over the world. Moreover, to give a best support to the students, the constructive relationship between the teachers and the parents is needed, and especially those parents with migration background. However, the collaboration between the parents (especially those with migration background) and the teachers is mainly difficulty and/or not possible because of the linguistic difficulties or different attitudes about the role of the school and education (Cooper, 2001; Xia, 2009).

Keeping this in mind, the aim of the present project is to sensitize students with migration background and their families/parents for chemistry and science in general and to raise their interest and motivation for this school subject(s). Furthermore, the integration of the parents in the project should reduce the barrier of parents` participation at school projects as well. The project is based on an offer of different experiments in different schools in the Federal State of Bremen (Germany). Those schools are mainly in the part of the city, where families with lower social-economical background and high percentage of families with migration background live. The researchers from the university were visiting schools in the afternoon after the regular class and invited students and their parents to join this offer and experiment on chemistry phenomena. All the experimental procedures were accessible not only in German language but also in different languages as well, e.g. Russian, Polish, Arabic, Turkish, English, Croatian/Serbian/Bosnian. Additionally, the supervisors from the university were native speakers in one of the named languages.

The focus of the research in this study is the cooperation between the parents and the students. The characteristic of the cooperation is seen as an intensity of parental support. Additionally, parents` attitudes toward chemistry were analyzed as well. Finally, the effect of the language support during the project has been analyzed. Data collection has been done qualitative and is based on a triangulation: (i) passive observation, (ii) interviews with the parents and students and (iii) supervisors` reflections and reports after every offer.

In sum, the results show that parents and students had positive attitudes towards the project. However, it was hart to motive the parents to attend this offer, although they register for the participation. The cooperation between the students and the parents can be described as intensive; nevertheless there were differences between the parents from different cultures noticeable. Positive reviewed were the materials in difference languages and the supervision in native language. In the presentation the concept of the project, the single materials and further results will be presented. The conclusion for the further work with the students and their parents will be given.

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Adapting Participatory Action Research for Developing Chemistry Sudent Teachers` Diagnostic Knowledge

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Diagnostic knowledge is one of main competences that future teachers in general and future chemistry teachers in particular should possess. This knowledge appears and is needed whenever one deals with heterogeneity, models of lesson design and individual support (e.g. Loughran, Berry & Mulhall, 2006). In general, diagnostic knowledge is described as knowledge about students` learning, their social skills and evaluating any other students` activities in the classroom. In addition, diagnostic knowledge is important for an appropriate diagnosis of students` learning conditions and their obstacles for successful learning. The results and observations from the diagnosis help chemistry teachers in their lesson planning and thereby in the analysis and development of the own lessons. In the present project the definition of diagnostic knowledge by Jäger (2007) has been used, where three main competences are described: (i) conditional knowledge–knowledge of the effects and the possible manifestations of a given survey, (ii) technological knowledge–the ability to select the most appropriate data collection and analysis methods for diagnostic questions, and (iii) knowledge of change–knowledge development which includes the application of strategies dealing with changing the experience and behavior of those involved in the interaction. However, first of all, chemistry student teachers need to be sensitive for diversity and heterogeneity in their future classes.

Since the importance of diagnostic knowledge with the view of rising diversity and heterogeneity in schools, there is a need for including diagnostic knowledge in higher education courses. To reach this aim, special methods were developed and implemented in two different chemistry education courses at our university. In the first step the competences were collected, which need to be thought in the seminars. Further, the model of Participatory Action Research has been used. This original model by Eilks and Ralle (2002) has been well established for the development of teaching and learning materials for secondary school (Eilks & Markic, 2011). By using this model it was possible to develop many materials for secondary chemistry lessons. Thus, the courses have been developed by adapting the model of Participatory Action Research for higher education.

However, it was noticeable that in some points there were limits of the original model during the adaptation to higher education. So for example the group line-up was changed, since more and different experts are now needed beside teachers and chemistry educators. Thus, difference to the original model of Participatory Action Research seems more productive if the work on a course development on diagnostic knowledge is a constructive exchange of practitioners with different experiences and theoretical knowledge in this topic, e.g. chemistry educators, chemistry teachers, special needs educators, language educators, intercultural education experts… Finally, the model has been extended, especially with the focus on the team and the cooperation partners. In the presentation the developed model will be presented and explained on an example about developing the course on linguistic heterogeneity. At the end of the presentation, the experiences with the developed model of Participatory Action Research will be reflected and indicated.

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Small children's non-formal chemistry education virtually at homes – parent's needs for support

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Parents needs for participating in Virtual Science Club at homes with 3-6-yrs-old children were studied as a case study. Interviews (n=7) revealed that parents must be considered as learners too. Support is needed in three areas: Affective, Organizational and Knowledge. To engage parents, these needs should be addressed by the learning environment.

The aim of this study was to find out what opportunities and challenges parents find in participating in developed non-formal Virtual Science Club with their children. Parent's attitudes towards science have an effect on children's future attitudes (e.g. Mantzicoupoulos et *al*., 2013). The origins of children's interest towards science can be traced to early interactions in the context of science with parents (Maltese & Tai, 2010). However, there is only a few attempt to bring science homes. In order to engage parents in children's non-formal science learning, we developed a virtual learning environment that encourages parents and children to learn and experiment together. The Virtual Science Club was designed in the previous stages of larger design research (Edelson, 2002).

This study was conducted as a single case study. The focus was on parent's views on opportunities and challenges that emerged from participating in the Club. 7 parents were interviewed in a phone. The narrative and semi-structured interviews were used with stimulated recall method. Interviews were analyzed by grounded theory.

As a result, there was formed a model that explains what kind of support parents need to do science activities with children at homes. There emerged three factors: 1) Affective factor, 2) Knowledge and Skills factor, and 3) Organizational factor. Parent's interest must be addressed in order to keep them engaged. It was not enough of motivation for some parents to see how exited children were to experiment. A parent needed more personal motivation. Parents needed support for understanding the scientific phenomena themselves, how to explain it to a small child and how to help a child find out answers. Parents needed an external organizing body that would give a schedule for experiments, send reminders and give feedback.

As a main conclusion, we need to consider that there is two learners–a parent and a child–with different needs for support. Parents usually start science-programs with great enthusiasm but quite soon, they will give up (Shymansky, 2000). Virtual learning environment can offer more personalized support for parents than e.g. science packages that are sent home. If the virtual learning environment would offer parents with support of all three areas, they would more likely to continue non-formal science learning with their children. In the future, special support for parents will be developed on the base of the results.

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Multimedia in Chemistry teaching in Portugal: a review of recent research

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Abstract

The recent Portuguese research on multimedia in science teaching was reviewed. The *corpus* consisted of *75* works. Most chemistry research was non-experimental, tackling content of all school levels via varied media and pedagogical approaches. Changes in research and practices are needed to foster the use of multimedia as cognitive tools.

Introduction

Multimedia is said to enlarge the possibilities in science education. But what is known about the pedagogical integration of multimedia? This study aimed to understand (1) what, how and what for is multimedia used in science (and chemistry) education and (2) how it is being studied.

Methods

We conducted a review of the Portuguese Master dissertations, PhD thesis and conference papers published in the period between 2010-2014 (Paiva, Morais, & Moreira, 2015). We searched the online repositories to include the reports on empirical research with Portuguese students (K5-K12). The *corpus* consisted of *75* works (8 reports on chemistry education). A content analysis was run. Interventions were coded according to the TPACK framework (Mishra & Koehler, 2006) and the methodological designs as experimental, quasi-experimental or non-experimental (Campbell & Stanley, 1966).

Results and discussion

The multimedia covered all the years applicable in a variety of formats. The multimedia was used to address core content (in chemistry, classification of the materials and reactions) but also transferable skills. Interventions were mostly co-constructivist. In chemistry, 4 interventions employed co-constructivist approaches, 3 transmissive approaches and one a dialogic approach. The majority of the designs were non-experimental (6 in chemistry), using relatively small samples (<30). Mixed methods were preferred. The significance of the study is that more participatory, longitudinal and experimental studies (mobile devices, georeferencing, virtual and augmented reality, 3D printing) are needed to foster the use of multimedia as cognitive tools.

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A design-based research: Student-centered chemistry education through the use of students' questions

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Students` own questions have been suggested to be a resource for teaching and learning (Chin & Osborne, 2008; Herranen & Aksela, 2016). Promoting student-centered pedagogy in chemistry education through the use of students` questions is a novel and promising approach. Student-centered education has been described, for example by higher education students, as an interactive approach, where students are "more responsible for and in control of their own learning" (Lea, 2003). However teachers` role in classroom practice is central (Appleton & Kindt, 1991). Therefore teachers` attitudes towards the students` questions should be studied. It has been studied previously that attitudes can be changed through reflection about their own teaching (Watts, Alsop, Gould & Walsh, 1997).

Student-centered pedagogy, especially students` questions in science, such as chemistry, is studied by a design-based research (Edelson, 2002). A study reported here has been studied within a development project "Good question". In the project eight elementary teachers and the researcher developed in co-operation methods to implement student-centered education into the classroom, especially by using students` own questions. The research questions are: i) What kind of attitudes do the teachers have in the beginning and end of the process to use the students` questions in teaching? And ii) What are the characteristics of the pedagogical models developed in the project? Teachers` attitudes have been studied by a semi-structured interview, instrument based on a former instrument on elementary teachers` attitudes in science (Van Aalderen-Smeets & Walma van der Molen, 2013).

The results of the initial analysis of the teachers` attitudes reveal for example how they see the benefits and challenges of the approach. The benefits according to the teachers are for example that students` remember the things asked in the class better than the things they read from the book. The teachers reported that one of the big challenge is that neither the teacher nor the student appreciates the students` questions enough to use them in teaching and learning. The study reveals how the teachers see themselves as promoters of the students` questions, and what kind of needs are there to be met.

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Chemistry in context: a curricular project for high school education. Strengths and weaknesses from teachers' and students' feedback

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Abstract

Preliminary research results of students' perceptions after the implementation of context-based chemistry modules of a curricular project for high school students are provided. Theoretical framework and features of created teaching materials are analyzed, and weakness and difficulties are discussed after results of a teachers' survey.

Although all chemistry context-based projects have common characters, they also have specific individualities in their conception and form, in addition to the topics chosen to develop units. One of the goals of all of those materials is to engage students and attract them by a view of chemistry fully linked with the uses of chemistry and everyday life.

In Catalonia, there was a new Chemistry curriculum (2008) that emphasizes contextualization, and which includes some contexts as contents, promotes experimental work and the use of ICT, and underlines inquiry, modeling and argumentation as key chemistry competencies. Our project fits with the approach and content of this curriculum and has a didactic approach using current trends on context-based materials and modules.

Further to that, and with the purpose of awakening interest in chemistry as a key to learning, the most remarkable features of the "Chemistry in context" project is to give meaning to content across contexts with the aim of introducing and constructing concepts in the context of the modules. Activities for appropriation of the objectives, evaluation proposals, and synthesis activities are included, as well as activities from videos of experiments and activities using simulations, MBL and other ICT resources.

The results of student questionnaires (nearly 150 in 5 schools) showed that students found classes pretty interesting (more than 60%) or very interesting (around 30%). Similar rates were found in questions about the feeling about having learnt chemistry. Students said that they have had to work hard (45% pretty hard and 45% very hard approx.) and nearly 80% considered most of activities performed difficult, although a similar percentage of students considered that activities were interesting. The results of assessing were regular (over a 35-40%), the same percentage good or very good, and the rest bad. Most students realized that they had learned a lot of chemistry uses and had valued learning chemistry as important and useful for everybody and for everyday life, and had a positive attitude towards chemistry.

Feedback from teachers has been accurately analyzed. The most relevant remarks among teachers that used teaching materials for first time were that it had been difficult to select and decide the essential key activities. To solve this problem and to better help teachers, teaching guides have been developed to establish basic itineraries with the key activities, and give teachers suggestions to address diversity and build versions adapted to different types of students and objectives, and also use some activities for continuous evaluating.

The current version of the project is the result of innovative team work by teachers from CESIRE that have adapted activities from previous versions, as well as elaborating new ones and having experienced them. During the last few years, teacher training courses have been performed so teachers can be accompanied in the implementation of activities and modules of the project and share experience and results. Modules are available on the internet in a digital format in https://sites.google.com/a/xtec.cat/quimica-en-context/

Context and topic – which aspects of context-based chemistry problems do upper secondary students perceive most relevant and interesting?

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To develop chemistry education towards higher order thinking, i.e. beyond recall of factual knowledge, context-based learning (CBL) approaches have in some countries been implemented to improve students' affective responses, as well as to develop their cognitive learning outcomes. To elaborate CBL approaches further, Pilot and Bulte (2006) highlight the need to identify contexts that both are appreciated by students and that can be related to the learning of chemical concepts. In some previous research (e.g. Christensson & Sjöström, 2014; Graeber & Lindner, 2008), the contextual setting has sometimes been named "topics", "modules" or "themes", and the definition of the different aspects has not always been explicit. In this presentation, students' affective responses, i.e. their perceived interest and relevance, towards specific aspects of context-based chemistry problems will be presented. The affective responses have been scrutinised by Stuckey et al. (2013) and will be discussed further in the presentation. The research question for this study is: Which aspects of context-based chemistry problems are found more or less interesting and relevant to students?

For this study, context-based chemistry problems were developed according to structured design principles; 15 tasks in five different topics (i.e. medical drugs, soaps and detergents, fuels, energy drinks, and fat) and three contextualized settings (i.e. personal, societal, and professional context). The reasons for choosing these topics and contexts are related to previous research (cf. the ROSE-project, de Jong, 2008). In the presentation, students' affective responses to the chemistry problems will be surveyed. Through semi-structured interviews, 20 upper secondary students (age 19) read and assessed these 15 problems regarding how relevant and interesting they were perceived before solving the problems according to think-aloud techniques. Thereafter, 175 students responded to the same affective questions, then in a written format.

One of the first outcomes is that the students found it difficult to distinguish between relevance and interest, a result also highlighted by Stuckey et al. (2013). After discussing the two concepts further, it was apparent that students found aspects relevant if they were valuable to themselves, e.g. to discuss different fuels was perceived relevant as the students were 19 years old and often had a driving license; however, the topic of fuels was not perceived very interesting. On the other hand, all five tasks with personal contexts as well as the topics medical drugs and energy drinks were perceived most interesting. In the presentation, students' affective responses will be discussed in relation to their cognitive responses investigated in previous research, i.e. students' conceptual responses (Broman & Parchmann, 2014). Implications for teaching from this study are that students often find chemistry interesting and relevant when it is closely related to themselves; chemistry topics and contexts that have explicit personal connections are perceived both interesting and relevant.

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Using active learning in the classroom: teacher and student experiences

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Abstract:

In the Irresistible-project, current science is introduced to high-school students by active learning approaches. Here, we looked at how teachers and students respond to active learning, and how this helps learning. The results show that learning scientific content in a creative way helps understanding and gives students a different focus on science.

Introduction:

Student's exhibit

In the Irresistible-project, current science is introduced to high-school students by using different active learning approaches (1). An adapted version of Roger Bybee's 5E-method of Inquiry Based Science Education (***Engage, Explore, Explain, Elaborate and Evaluate***) was used to structure the educational material (2). In the Elaborate-phase, students debated about ethical aspects of the science topics, based on learning about Responsible Research and Innovation (RRI) (4). In the Irresistible -project, a 6th E was added to the 5E's, Exchange in which students built exhibitions about the topics studied. Main goal was that the exhibitions could be used to show others what they learned. Teachers were encouraged to use the EXPOneer system, developed by Kampschulte et.al. (3), to design low-cost exhibitions with students. This has resulted in a number of exhibitions at different schools.

Methods:

In the Netherlands, three modules introducing current science research have been made available for teachers: a module about carbohydrates in breastmilk for biology/chemistry classes, about nanoscience and its applications for chemistry/physics classes and about the Polar Regions for biology classes. All these modules use the active learning approaches described above. In this study, the main focus is on how teachers and students respond to active learning, and how active learning helps the learning process. Participating schools were visited, when the students finished the project. The exhibits were scored on scientific content and RRI-aspects to determine how well students learned the scientific material. Teachers and a focus group of students were interviewed about their activities during the project. Teachers were specifically asked about how they felt skills like creativity and group work improved learning during the project.

Results:

The results of this qualitative study show that working with scientific content in a different/creative way helps the students' understanding of the topics, and gives students a different focus on science. Teachers were positive about this method because: '***so-called 'soft skills' are becoming more important for students, also for those who aspire a science career***.' Students indicated that they appreciated the active learning as opposed to the traditional learning methods mostly used in schools, and that knowledge is retained longer.

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Food Science Students' Understanding of Chemical Kinetics

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Abstract

Students' understanding of concepts in chemical kinetics is particularly important for food science students. For instance, these students will generally deal with various enzymatic processes in their courses or research that require an adequate knowledge of chemical kinetics, such as order of reaction and related concepts. The aim of this study was to identify food science students' understanding of concepts in chemical kinetics. 80 food science students in Year 1 at the University of Reading studying a fundamental chemistry module participated in the study. Multiple choice and short answer question tests were used as instruments. A number of students who gave unclear explanations in their answers were followed up in an individual interview session. The results showed that the students' difficulty in understanding this topic can be categorized as misconceptions, lack of knowledge and mathematical weakness.

Generally, students' difficulties uncovered in this study are similar to those published by previous researchers. For instance, that the increase in concentration of zero order reactant increases the rate of reaction is strengthen the result published by some previous researchers. However, several findings that have not reported previously are revealed in this paper. One of the new findings uncovered in this study is that students believed that the equal numbers of reactant molecules lead to a higher reaction rate. Therefore, they argued that if both reactants (i.e. X and Y) are equal in concentration, the maximum amount product will be formed. In addition, students' carelessness in responding to questions played a role in students' unscientific answers.

Keywords: chemical kinetics, students' understanding, misconceptions, lack of knowledge, mathematical weaknesses

Investigations for Pre-service Chemistry Teachers

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Abstract

Student led investigations/projects are now part of the second-level science (chemistry) curricula in many countries across Europe. Preparing pre-service teachers to feel confident and competent in conducting such investigations is challenging. This paper discusses two such approaches and highlights areas of student learning and difficulty.

Initial chemistry teacher education is demanding as not only have the students to increase their knowledge of and about chemistry but they also must develop skills and competencies in teaching methodologies and assessment practices appropriate to their discipline. Many curricula at second level school now include inquiry practices, which include student-lead investigations. To this end, the pre-service teachers must have experience themselves of carrying out a chemistry investigation so that they can identify and support their students in doing such a task (Guidebook of Good Practice, 2015).

As a learning activity, student led investigations (both at 2nd and 3rd level) are beneficial as they provide experiences in many (if not all) of the inquiry skills – such as searching for information, applying knowledge from different sources, making basic decisions about scientific processes, apparatus, etc, examining results, deciding on experiments that will confirm results, validity of results etc. When planning a student investigation, many teachers select the investigation as they already know the answers themselves; however, how do student teachers react to conducting investigations where it is indeed a 'genuine' investigation in that they do not know the answers themselves?

To this end, two groups of pre-service teachers in the third year of their pre-service programmes (in Krakov (N=32) and Dublin (N=12)) were involved in conducting investigations in chemistry; the Krakov group had to plan projects for use in second-level school, checking all experiments / investigations proposed, while the Dublin group had to pose a question to investigate around the topic of food and conduct investigations to answer their question. This paper analyses the different approaches used by the two groups from an organisational perspective (e.g. time allocated, open vs guided approach), a knowledge perspective (the practical and theoretical knowledge gained by the pre-service teachers themselves), the applicability of the approach or plans in their own teaching and the difficulties they experienced in conducting the investigations. From analysis of the approaches used, responses given by the students to interview/questionnaires, evaluation of presentations and reports, we can also draw some conclusions about difficulties they experienced and what they have learnt through the process. General recommendations will be made to enhance the use of investigations within the pre-service teacher education programmes.

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Foundation year medical student perspectives of an inquiry Based chemistry programme–POGIL (Process Oriented Guided Inquiry Learning)

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Abstract

Student perspectives of a voluntary pre-lecture chemistry programme based on POGIL activities are presented. Most frequently cited benefits of POGIL programme refered to understanding and teamwork skills. Most frequently cited weaknesses were time or duration of programme activities and live feedback.

Aims: Identify factors that determined student motivation to participate in a voluntary pre-lecture chemistry POGIL programme. Identify perceived benefits and areas of strength and weakness in the voluntary pre-lecture chemistry programme and its activities.

Methods: At the end of the voluntary POGIL programme a 26 item online questionnaire, containing Likert and free text items, was administered to the foundation year class capturing responses from 3 student groups (POGIL participants, students eliminated from POGIL programme and non participants).

Results: From a class of 140 foundation year students, 100 responses to the questionnaire were recorded. Student perceptions of the POGIL programme, its benefits, areas of strength and weakness are presented. The most common benefit associated with the POGIL activities, as identified by students, was 'increased understanding of learning material'. 'Lack of perceived benefits' and 'time constraints' were commonly cited by the non participant group as reasons for not participating in the programme. The participant group had the highest levels of agreement with items indicating the activities increased deeper understanding of concepts and development of teamwork skills. Areas of weakness identified by all groups were the timing of the events, workload and their duration. The scarcity of live feedback during the activities was frequently cited by the participant group.

Conclusion: Student perceptions indicate that POGIL is an effective student centered learning approach which has been successfully applied in a voluntary foundation year chemistry course in a medical programme. Its application in the subject areas of chemistry that require deeper understanding of basic chemical concepts is appropriate and it is expected to be more effective as an integrated component of the chemistry course as opposed to being a supplementary programme. Improved participation, may be achieved by more suitable timing of activities, reduction in workload and duration of activities in addition to improved mechanism for delivery of live feedback.

Labdog: A novel web-technology to enhance learning in the lab

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It has been over thirty years since Johnstone (1982) first laid down his triangular nature of chemistry. That is that chemistry operates across the macroscopic (i.e. what a student can see with their naked eye), submicroscopic (e.g. atoms, molecules, and bonds), and symbolic (e.g. structural or skeletal formula). Understanding how these dimensions are discrete, yet often simultaneous is an essential yet difficult part of becoming a chemist (Johnstone, 2000).

On the surface the chemical laboratory it is an excellent way to link macroscopic phenomena to its underlying submicroscopic chemical processes. While the lab ***can*** introduce, support, and reinforce the chemical concepts, in reality educators and students often focus on the macroscopic processes of ***doing***, rather than the chemistry behind it (Reid and Shah, 2007). This is evident in lab-scripts, i.e. the step-wise list of instructions which students follow during a lab. Lab scripts have been critiqued as "'cookbook[s]' in nature" (Domin, 1999, p.109), which do not promote the more beneficial process of open or guided enquiry (Abraham et al., 1997; Abraham, 2011). Given the ubiquity of teaching labs in universities, and their associated financial and time costs, fulfilling their pedagogical potential can widely improve teaching and learning practices.

This presentation will discuss the development, implementation, and evaluation of Labdog, a piece of novel web software designed to question students during a practical. Labdog facilitates the digitisation of lab scripts, also allowing for questions and requests for photographs to be inserted at any point. Questioning alone has proven beneficial to STEM (Freeman et al., 2014) and chemical (Wijtmans et al., 2014) education specifically. Research into students' processes during undergraduate laboratories calls for "purposeful checks on their understanding" (Galloway and Bretz, 2016), and Labdog was designed to facilitate just that, as well as providing opportunities for self-assessment and reflection.

Labdog was developed for the 2015/16 academic year and so far has been used by the Science Foundation Year (SFY) students at the University of Southampton in their bi-monthly practicals. Preliminary results suggest that students are positive about Labdog as a learning tool, but have concerns about the added time and cognitive demands of answering questions alongside their ***regular*** lab activities, e.g. their lab notebook. Additionally Labdog has provided insight into student understanding and reasoning of chemical processes, suggesting that students do not necessarily arrive with, or derive, correct chemical understanding of the practical itself.

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"Creating creativity": Improving pre-service teachers' conceptions about creativity in chemistry

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Although creativity is considered as one of the key competencies in modern society and as a central aspect of nature of science, it has been neither established as a main topic in chemistry education research nor in today's chemistry education practice [1]. As a result, students mostly characterise chemistry as a solely logical and analytical discipline and do not appreciate the importance of creativity in the development of chemical knowledge. The research project tries to address this deficiency. Based on the assumption, that adequate conceptions of chemistry teachers represent a necessary condition on the way to implement nature of science into chemistry education appropriately [2], the focus is on pre-service chemistry teachers. The principle aim is to find out, how they can be supported in developing appropriate conceptions about creativity, about the role of creativity in scientific research processes, and about possibilities to implement creativity into chemistry lessons.

For this purpose, different approaches were evaluated in several preliminary studies in pre-service chemistry teacher courses at the University of Cologne. Some approaches included historical or contemporary examples of creative research processes, others enabled the teacher students to become creative themselves [3]. The findings indicate, that two approaches are particularly suitable to foster adequate conceptions about creativity in chemistry: a case study about Jacobus Henricus van't Hoff (1852-1911) and the development of his models about the spatial arrangement of molecules [4], and offering the teacher students opportunities to generate analogical models to educationally relevant chemical models by themselves [5]. While the first approach enables the teacher students to recognize *that* creativity is important in chemistry, the latter offers the opportunity to realise *how* creativity works in chemistry.

Assuming that a combination of both would be most efficient, an appropriate course unit is conducted in the final and main study of the project, in winter term 2015/16. Data are collected by open-ended questionnaires, semi-structured interviews and participant observation. Results and implications will be discussed in the presentation.

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Biology and Chemistry Preservice Teachers' Opinions towards the Nature of Science (NOS)

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One of the essential component of science education is developing students' scientific literacy together with acquiring the science content. Achieving scientific literacy, of which the Nature of Science (NOS) is an important component, is vital for individuals to make informed scientific decisions and become more productive citizens. Hence, NOS in our country, as it is in many countries all around the world, is a part of science curricula (Şardağ et al., 2014). But, research reports that Turkish students, prospective teachers and teachers' opinions and knowledge towards NOS are inadequate and also embeds misconceptions in addition to failure of the science program in developing the students' opinions to NOS (Altun-Yalçın et al., 2010; Çil and Çepni, 2012). One of the primary causes of these deficiencies is probably teachers' knowledge of NOS and their practices in classroom. Thus, the aim of this study is to determine preservice science teachers' opinions towards NOS. Data were collected through a Likert type "Nature of Science Scale", which was developed by Özgelen (2013) in this survey study. The scale was applied to totally 179 biology (65 female, 31 male) and chemistry (52 female, 31 male) preservice teachers who are studying in Kazim Karabekir Education Faculty at Ataturk University. The findings indicated that prospective teachers have generally mixed opinions towards NOS. The findings also indicated that there was a statistically significant difference in terms of gender and department that studied.

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A study of the perception of Chemistry in young generations and of their chemical/scientific knowledge in Italy

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In this research, we have explored how Chemistry is perceived by young generations in Italy. To perform this study [1], we have developed a test, composed by closed and open questions and divided into three main parts in order to assess: ***i.*** the personal information data; ***ii.*** the attitude towards Chemistry and ***iii.*** the scientific-chemical knowledge. After projecting the test, it has been shared on-line through social networks (i.e. faceboook, twitter and google) [1,2]. The data obtained over about 350 young people, who fully completed the test, were then analyzed. The obtained results are here discussed, underlining the similarities and the differences in comparison with the current situation in the UK [3]. The chosen target sample included a large majority of university students who had selected different educational paths. A section of the test has been dedicated to questions designed to assess the general public's knowledge of chemistry. This choice is justified by the necessity to understand how much people really know about chemistry whilst giving their feedback about the subject in the section dedicated to the perception of chemistry. The results of the test support this choice.

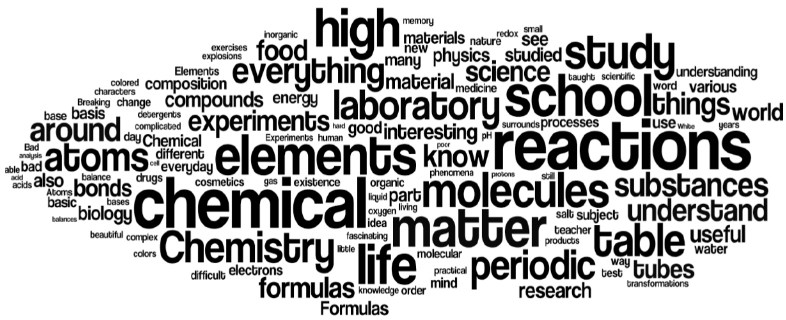

Fig. 1. Cloud of words associated to "Chemistry" by the young people participating to the present research [1].

The young population represented in this study, mainly composed of people under 30 years old, offers a good image of the young Italian generations that attended or are attending university, so can also be representative of the state of the current Italian educational system.

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What is chemistry today? Analyzing the image of chemistry from twitter messages

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Abstract

Chemists have been concerned about the public image of chemistry for a long time. That's why we collected 500 tweets including "chemistry", "chemical" or "chem" per day for the first semester of 2015. The most frequent terms and recurring and omitted topics are analyzed.

Communication

The aim of the research is to identify the most and least frequent topics about chemistry in Twitter being a driver to detect the public image of chemistry.

Based on the extraction of 500 tweets per day (60,000 in total) containing the words "chemical", "chemistry" or "chem" between the dates of January 1st and June 30th, 2015, retweets and duplicated tweets were removed and the rest were classified by language as well as stored only those identified as written in English. These were pre-processed by converting them to ASCII, removing punctuation, retweet codes, links to web pages and extra spaces between words. Each tweet was included was included only once in the dataset, even if repeated.

The entire datasets were analyzed using unigrams and bigrams bag-of-words. Visualization was achieved using wordclouds.

Figure 1: Wordcloud of bigrams for the tweets containing term "chemical" (excluded)

The messages were grouped using k-means into topics. Preliminary results suggest that topics detected in tweets that contain the word "chemical" are different from those containing the words either "chemical" or "chem". Topics related to chemistry as a science or related to its everyday relevance are essentially missing from the conversations.

How do students' interest and conceptual understanding develop over the time of their secondary chemistry education? First results from the binational project dolis

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Learning outcomes in chemistry education are multivariate: Students should, for example, learn the basic concepts and methods, develop interests, become motivated to engage in further learning processes and societal discussions, and gain insights into professional career perspectives for their own future. While chemistry is a subject that is highly relevant in everyday life, that has many career perspectives, and that offers inspiring activities in class, such as carrying out investigations or observing surprising phenomena, research in chemistry education has shown low values for students' interest and the perceived relevance of chemistry (Sjøberg & Schreiner, 2012; OECD, 2014). In addition, research indicates that students have difficulties in understanding and applying the basic concepts of chemistry and the nature of science (Bernholt et al., 2012; Osborne & Dillon, 2008).

When regarding this situation, substantial differences between countries become obvious (Sjøberg & Schreiner, 2012). For instance, the PISA test results in science for Sweden show a negative trend from 2000 to 2012, while the trend in Germany was positive (OECD, 2014). This is interesting since both the social structure and the culture of these countries are similar. In both countries, chemistry is learned in an integrated manner with other science subjects up to grade 6, and thereafter mostly as a separate subject. To better understand these totally different developments and also how these effects come into play over the time of schooling, a cross-sectional study was carried out in Germany and Sweden in 2015 with a total of $N = 5096$ students ranging from grades 5 to 12. This cross-sectional study was also the starting point for longitudinal studies in two cohorts, following up on students from grade 5 to 8 and from grade 9 to 12 for the purpose of investigating changes in the early stages of secondary education as well as in the transition phase into upper secondary education.

At the different time points, students' conceptual understanding regarding fundamental concepts (matter, chemical reaction, energy; cf. Hadenfeldt et al., 2016), their interest (differentiated by realistic, investigative, artistic, social, enterprising, conventional, and networking activities in chemistry; Blankenburg et al., 2015), and other central goals of chemistry education (motivation, epistemological beliefs, self-concept) as well as classroom and teacher variables are assessed. Regarding the cross-sectional study, results indicate that students' conceptual understanding increases by grade (albeit in a different pace with regard to concept and countries), while their interests in scientific activities generally decline by grade. However, the structure of interest in chemistry seems to differ by country, which might also be a cause for different trends in students' performance. At the conference, these results will be complemented by results from the first longitudinal wave. Here, students in grades 6 and 10 participated again in spring 2016, offering the possibility to analyse the development of the different measures on the individual level.

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Promoting Understanding Over Rote Learning: Self-Assessment in Mechanistic organic chemistry

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Chemistry is renowned as a challenging subject to its students, due to the abstract nature of many essential concepts that can lead to misunderstandings and hinder learner progress (Zoller, 1990). More specifically, organic chemistry is considered as a highly challenging topic at university level (Bradley et al., 2002).

It is important to help students adopt a meaningful learning approach and think mechanistically, as research has shown that students who think in this manner are likely to be better organic chemists (Grove, Cooper, and Cox, 2012). Despite this, it has been seen that the predictive capability that should arise from mechanistic proficiency is absent amongst many students (Kraft, Strickland, and Bhattacharyya, 2010).

Formative assessment provides students with feedback to improve their learning and subsequent performance. Indeed, formative assessment, in the form of self- or peer-assessment, has been shown to be beneficial to students' learning and understanding (Black and Wiliam, 1998). The use of self-assessment to support students in the study of organic chemistry has been tested at undergraduate level, and was well received by students, with many feeling more confident and knowledgeable in the subject as a result of their participation in the task (Brown, Hinks, and Read, 2012).

This presentation will outline a study in which a package of self-assessment exercises for school-level students was developed with input from practicing schoolteachers. These, along with a set of 'talking mark schemes' to support students in assessing their own work, were distributed to schools and colleges for delivery. During 2014/15, over 560 students in the UK took part in the study and contributed to the evaluation process, providing valuable insight regarding the benefits of the approach and its impact on students' understanding and confidence. The project is continuing in 2015/16, hopefully with a larger cohort of participants.

In 2014/15, 86% of participating students agreed or strongly agreed that the process furthered their understanding of mechanistic organic chemistry, and 91% indicated that they would like access to resources of this type again in future. Analysis of the qualitative data obtained provides valuable insight regarding the value of self-assessment in helping students to change their perceptions of organic chemistry. Additionally, some teachers reported that they had begun to develop similar resources for use with their own students either as a result of participation in the project or exposure to its outcomes. In the current study, we are investigating the correlation between students' confidence levels and their summative performance (i.e. the Dunning-Kruger effect, a cognitive bias that leads weaker students to over-estimate their capabilities (Pazicni and Bauer, 2014)), as well as students' attitudes towards rote-memorisation, and whether they think it is an effective way to learn organic chemistry.

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Application of three-tier test to assess students' misconceptions about lipids

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There is probably no aspect of teaching that has been devoted more attention, over the last few decades, than students' misconceptions. Accordingly, various diagnostic tools for their identification have been developed during that time. After interviews and open-ended tasks, researchers began to apply less time-consuming forms of testing: common multiple-choice tasks and multi-tier tasks. More recently, three-tier tests have been highlighted as exceptionally reliable, valid and efficient instruments for identification of students' misconceptions [1–3]. Following this, the aim of this research was to develop and validate three-tier test and to reveal students' misconceptions regarding Lipids. Testing was performed in Chemical Technology School in the city of Subotica (Republic of Serbia) in two third grade classes with a total of 46 students. Developed test consisted of 10 three-tier tasks, first tier of which was a content tier, second a reason tier, and third a confidence tier. This test was shown as highly reliable diagnostic tool, with high values of Cronbach's alpha coefficient for all three tiers, and valid diagnostic tool, satisfying both construct and content dimensions of validity.

The main findings of this study revealed several prevalent misconceptions among examined group of students regarding Lipids. However, additional comparisons of three-tier and two-tier results showed that number of identified misconceptions would be considerably higher if the third tier was not considered. Namely, third tier imparts valuable information about students' confidence thus providing an ability to distinguish between misconceptions and lack of knowledge.

Additional task in this study was related to the assessment of students' understanding. Similar to the analysis of misconceptions, two-tier results overestimated students' understanding, while three-tier results provided more accurate information, attributing some correct answers to the lucky guessing instead of students' understanding. It is worth mentioning that this study aims to shed light on the application of three-tier test on chemistry contents, which is not sufficiently used in comparison to its application on some other natural sciences contents.

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Designing scaffolds to teach chemical bonding through Laboratory Inquiry

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Abstract

This paper analyses how pre-service secondary Chemistry teachers apply their knowledge about scaffolding provided (previously learned) to help high school students solve an inquiry-based laboratory task about chemical bonding and reactivity. The main findings point to imprecise resources developed.

Proposal

The goal of this study is to examine how pre-service Chemistry teachers design scaffolding resources that help students solve an inquiry-based laboratory task about chemical bonding. The analysis focuses on how they apply what they have learned when they are required to design scaffolding tools that help students to solve a task about chemical bonding and reactivity in 10th grade (16 years- old students). To do so they are provided with the following extract of a task: ***"As managers of the city council laboratory, you receive an anonymous complaint of a possible pollution caused by some of the factories operating in the industrial park close to the local river. So you are required to analyse some water samples in order to verify it. To solve the problem you need to design and implement an investigation in order to identify the factory or factories responsible for the pollution."*** In addition they are provided with the names of the factories and the substances used to produce their products. Participants are expected to complete the handout with some tips that lead students to use their knowledge about chemical bonding as well as to design some scaffolding tool that help students in the process of planning the investigation. For the analysis, participants' written proposals are examined in terms of the adequacy of the tips and the tools provided. The preliminary results point to a tendency of pre-service teachers to provide direct instructions instead of general tips that would close the openness of the task.

Characterizing the link between chemical identity thinking and biochemical contexts

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Various policy documents (e.g. ***A New Biology for the 21st Century,*** NRC, 2009) have called for sweeping changes in undergraduate biology and biochemistry education, which include moving students toward a more integrated understanding of interdisciplinary concepts, improving critical thinking skills, and increased disciplinary expertise. Biochemistry is an interdisciplinary field that demands a solid understanding of general chemistry concepts. Chemical identity is one such general concept in chemistry, and involves identification and differentiation of substances (Sevian & Talanquer, 2014). Since chemical identity is a foundational concept in chemistry, we hypothesize that knowledge of chemical identity is relevant for understanding and applying biochemistry concepts, and potentially critical to development of expertise in biochemistry.

For this study, we have used creative exercises (CEs) to establish and characterize students' usage of chemical identity concepts in biochemistry. Creative exercises are an open-ended assessment tool that has been used in chemistry (Ye & Lewis, 2014) and biochemistry courses (Warfa & Odowa, 2015) to analyze the linkages between foundational chemistry concepts and upper-level courses. A prompt is provided that sets the context, and students are asked to produce a certain number of statements that pertain to the prompt. The open-ended nature of CEs allows students to freely make associations between the provided context and students' prior knowledge. The CEs for this research are based on biochemistry contexts where chemical identity thinking has been deemed relevant by a survey of experts in the field of biochemistry. Data produced from implementation of these CEs in a second-semester biochemistry course have been analyzed for the presence of chemical identity thinking. Within student responses to the biochemistry contexts, chemical identity thinking has been revealed, and includes ideas such as identification based on compound classification or chemical structure and differentiation informed by composition or chemical properties.

Primary school students in chemistry laboratory: Inquiry, learning and experience in authentic environment

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The Department of Chemistry, University of Jyväskylä and LUMA Centre of Central Finland have had a wide-ranging cooperation with the Jyväskylä primary schools since 2006. In the spring of 2015 eight primary school groups worked in the university teaching laboratory: 82 sixth-, and 74 fifth-grade students (11 and 12 years, respectively) together with their teachers. The day at the university is intended to familiarize the students in experimental work. In addition, students are introduced in various fields of chemistry and methods of scientific inquiry. Also, chemist as a profession was introduced to the students.

One purpose of the visit was to introduce the students of different scales within chemistry. For example, visiting electron microscope helps students to visualize the different orders of magnitude in practice. This was achieved by using small and large scale images of the same objects, like coins, leaves of trees and small insects. These are all objects familiar to the students.

According to the existing national curriculum in Finland [1], primary school student is familiar with the names of elements and their chemical symbols, but have not been introduced into how molecules are built. This sets up another challenge for the visits in the laboratory: how to tell the students of atomic level structures in an understandable way and by appropriate examples.

A research questionnaire was used to evaluate the outcome of the laboratory visits. The questionnaires contained only open questions, where the students were asked to write their findings in their experimental work. Additionally, they presented their own opinions of the visit.

Based on experiences of visits and analysed questionnaires, the following conclusions and implications can be made:

The answers of the questionnaires highlighted the instructions given on beforehand for laboratory work and the use of protective equipment. Many of respondents cited laboratory coat, safety goggles and gloves as important and interesting to them, especially since this was the first time the students were working in a proper laboratory with its own rules and actions.

The comments received from teachers afterwards implied that the visit to the university had been discussed with the fifth-grade students on several occasions during the spring and the issue is returned to in the autumn when the students are on the sixth grade. The same happened with the sixth-graders, who have taken up the visits with their subject teachers in the following autumn. This is in accordance with the purpose of stimulating the students minds into chemistry and an interesting and important subject in school, and which has also importance in real life. This study and the visits serves as a valuable resource of ideas for future primary school visits at the university teaching laboratory.

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Chemistry Lab-centered activities for 6-10 years old children at the Science Museum.

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The context of science centers and scientific/technical museums is very effective for public engagement [1] and it influences positively the general public attitude towards Science and, in particular, Chemistry [1,2]. Science museums are also an ideal context for science teaching, through visits, interactive and laboratorial activities, as well as for teacher training [3,4].

In this presentation, we are reporting our main achievements obtained from an intense program of activities dealing different chemical topics and performed by children from several primary schools at the Science Museum, in the period from 2011 to 2015 [5,6]. Almost all these activities are laboratory-centered ones and they are projected and realized in collaboration with a group of undergraduate students attending the course of Chemical Education (University of Pisa) and their tutor.

Particular care is taken in projecting these activities, in order to merge the visit and the experiences at the museum with the science curricula built by the teachers. The assessment and the follow up of the activities at the museum represent an important part of the present research, as well.

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Engaging pre-service Primary Teachers in Scientific Practices: Planning an Investigation and Communicating Results

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Abstract

This proposal seeks to examine the process of engaging pre-service primary teachers in the practices of planning investigations and communicating scientific information, as well as their reflections about the potential of the task to achieve primary students' engagement.

Proposal

This study is framed in a perspective which considers that Science education should be aligned to professional Science, which means teaching and learning it in the way scientific knowledge is produced (Duschl, 1990; Duschl & Grandy, 2008) or in other words, engaging students in scientific practices (Achieve, 2013). In this paper the focus is on the practices of planning and carrying out investigations and obtaining, analyzing and communicating information (National Research Council [NRC], 2012). The main goal is to examine how pre-service primary teachers develop these practices as well as their reflections about the potential of the task to achieve primary students' engagement in scientific practices. The laboratory task requires students to plan and implement an investigation to help some detergent companies to unmask another that launched a new detergent presented in the media as being able to remove any type of stain by soaking clothes during 10 minutes in water. At the end of the process participants have to write a report explaining their methods and results in order to persuade the enterprise committee.

The main findings point to students' imprecise and incomplete performances. The need of engaging pre-service teachers in these practices and to develop resources that help them to engage in is discussed.

Chemistry by inquiry for initial teacher education

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Abstract

Pre-service teachers need to experience inquiry as a student so that they can develop attitudes and competencies to be able to teach through inquiry. This paper analyses how an inquiry module was developed and implemented within a pre-service programme for lower-second level science teachers.

Inquiry teaching and learning has been endorsed as an appropriate method for learning science in various reports and now has a place in many national curricula (NCCA, 2015; Ontario Ministry of Education, 2008). However, even though inquiry practices have been promoted over many years (NRC, 2000; Minner et al., 2010), many teachers struggle with inquiry due to their lack of understanding of inquiry, how to implement it effectively in the classroom, time required and perceived classroom management issues (Hong & Vargas, 2016; Laius, et al., 2009; Jackson & Boboc, 2008).

Therefore it is important that pre-service teachers are both exposed to inquiry practices in their initial teacher education and also that they experience inquiry as a learner themselves (Finlayson, et al., 2015). It is known that novice teachers frequently teach as they were taught due to their apprenticeship of observation (Borg, 2004). So in initial teacher education, they should become more confident and competent in inquiry instruction.

Informed by successful European projects on inquiry such as ESTABLISH and SAILS, a laboratory based chemistry module of 33 hours was developed for 2nd year pre-service science teachers, who will specialise in teaching of biology and physical education in 3rd and 4th year. The module focussed on teaching general topics in chemistry through inquiry and so the participants both experienced the learning through inquiry as well as learning about inquiry.

As the participants do not begin teaching for a further two years, it is impossible to comment on whether or not they have improved as inquiry teachers. However, the development of their own inquiry skills, their attitudes towards science, science teaching, and inquiry teaching can be mapped or determined. Preliminary results show that following the programme, the participants enjoy science more, feel more confident teaching science in the classroom, and are more comfortable with inquiry instructional methods. The development of the module and the overall results will be presented.

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How french students use the language of chemistry

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The chemist should learn to handle symbols and formulas (Laszlo, 2011), part of the language of chemistry, which has to be done in connection with the other areas of chemical knowledge, the macroscopic and microscopic ones (Johnstone, 1993 ; Kermen & Méheut, 2009; Taber, 2013;Talanquer, 2011). We wonder whether the students are able to make proper links with the macroscopic or the microscopic models when they use chemical names and formulas. According to our analysis of the curriculum, this topic is not covered at the moment in the teaching of chemistry in France, but we think that the students' difficulties concerning the use of the language of chemistry might be important. We conducted an investigation to find out what mastery of the language of chemistry French students have. We particularly wanted to determine whether they are able to properly associate characteristics of the macroscopic level (pure substance or mixture) and of the microscopic level (atom or molecule) to a name or/and a formula. We administered a paper and pencil test composed of two multiple choice questions to students (N=603) who have been learning chemistry for 2 years (age 14) and others for up to 7 years (age 19, first year university). The students are asked to choose one or more criterion among four (pure substance, mixture, atom, molecule) that they could associate to a name (question 1) or a formula (question 2). The students surveyed are not able to correctly associate with a name or a formula (table1), both macroscopic (pure substance or mixture) and microscopic (atom or molecule) criteria. However, the number of correct answers on the microscopic criteria improves with the number of years of study. Analysing the answers in depth shows that the students particularly struggle to associate macroscopic criteria to the names as well as to the formulas. The students do not seem to master the concepts of pure substance and mixture (Stains & Talanquer, 2007). Less than a quarter of the students in group 3 (age 17-18, N=147, students studying science in depth) answer correctly and more than 60% do not answer at all. These results confirm the need to offer teachers new didactical tools to develop the teaching of the language of chemistry.

Table 1. Example of percentage of correct answers for each formula and by grade levels

Correct answers **Students' group and age**	C	H_2O	O_2	CO_2	Fe	C_2H_6O
Group 1: age 14-15 (N = 233)	13%	6%	15%	5%	7%	2%
Group 2: age 16 (N = 178)	29%	8%	15%	3%	25%	2%
Group 3: age 17-18 (N = 147)	22%	12%	16%	6%	22%	4%
Group 4: university (N = 45)	49%	16%	33%	4%	36%	7%

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What makes a successful chemistry school?

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In Ireland Biology is almost four times as popular as Chemistry and Physics in the senior secondary cycle (age 16-17). Around 15% of the senior cycle cohort take Leaving Certificate (LC) Chemistry each year, but the popularity and uptake of Chemistry varies widely from school to another, even when they are of similar size and type. All students study the same science course in the junior cycle, which includes Biology, Chemistry and Physics, and so nominally have a common background when they enter senior cycle. Concern about the uptake of the physical sciences has been expressed for many years, culminating in the Task Force Report (2002).

We were interested to investigate why some Irish schools are more successful than others in attracting students to study Chemistry. If we could identify common contributing factors in successful schools then this might allow us to transfer or recommend them to less successful schools. This paper reports two studies, done as final year research projects by students on science teacher education courses. One was done in 2009 (LW) and the other in 2014 MMcC), with both attempting to answer this question: 'What makes a successful Chemistry school?'

We first identified schools where the uptake of Chemistry was significantly above the national average, using published data on the size of the LC cohort and the numbers entering the LC Chemistry examination in the same year. We termed these schools 'successful'. In the first study in 2009 we sent questionnaires to 35 successful schools in one geographical area, including a range of school types, and received 12 replies. In the second study in 2014 we identified 30 pairs of similar schools across the country, where one school enrolled above the national average for LC Chemistry and the other one below the average. The schools were matched by size and school type, to try and ensure comparability. Questionnaires were sent to all the 30 pairs, 60 schools in total, to try to identify factors common to successful schools and not found in less successful schools. Results from 8 complete pairs (16 schools) were obtained and analysed.

From the 2014 results we could identify common factors in the successful schools, which were similar but more extensive than those identified in the 2009 study. From the data we were able to generate a profile of an Irish second-level school that succeeds in attracting students to study Chemistry. This study gives us pointers towards what things to encourage and develop in schools to increase the uptake of Chemistry. Although Irish schools offer the same curriculum and a similar educational experience, they can vary widely in size, type (single sex versus mixed), style (academic versus vocational), location (rural versus urban), resources and intake. There can thus be a wide variation in the actual educational experience received by students, depending on which school they attend. These factors influence the view students have of science and particularly whether they want to study the physical sciences in the senior cycle.

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Secondary school students' perceptions of working life skills in science-related careers

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Abstract

This study focuses on school students' perceptions of abilities needed in science-related careers. According to the students chemist needs courage, calm, intentness, patience, caution, and safety in his/her behaviour. For example, responsibility was linked to pharmacist and chemist, and precision was pointed out in all careers.

Introduction

European employers prefer team working skills, sector-specific skills, communication skills, computer skills, ability to adapt to and act in new situations, good reading and writing skills, analytical and problem-solving skills, planning and organisational skills, and decision-making skills (European Commission, 2010). These 21st century skills could be grouped in four categories (Binkley, Erstad, Herman, Raizen, Ripley, Miller-Ricci, & Rumble, 2012):

Ways of thinking: Creativity and innovation; critical thinking, problem solving, decision making; and learning to learn, metacognition

Ways of working: Communication, collaboration (teamwork)

Tools for working: Information literacy (includes research on sources, evidence, biases, etc.); ICT literacy

Living in the world: Citizenship – local and global; life and career; personal and social responsibility – including cultural awareness and competence.

Students' conceptions of careers are stable through at least several years of adolescent (Masnick, Stavros Valenti, Cox, & Osman, 2010) and students have a strong perception that scientific careers are not particularly creative and do not involve much interaction with others. To increase the utility value of school science, providing students with information and advice about career options and the corresponding educational requirements was seen to be critical.

Method

The context of the study is the EU project 'Promoting Youth Scientific Career Awareness and its Attractiveness through Multi-stakeholder Co-operation' (MultiCo). The participants were 140 Finnish 7th graders (aged 13-14 years). Data were students' written descriptions of working life skills needed in some careers for example chemist, air traffic controller, pharmacist, and software designer.

Results

Students pointed out precision in most of the careers as well as sector-specific knowledge and skills. According to the students, horticulturalist needs sense of style. Social skills (collaboration) were linked mainly to pharmacist and nurse. Reasoning skills (decision making) were connected with nurse, geneticist, pathologist, and production designer. Responsibility was linked to pharmacist and chemist. Students perceived that chemist needs also courage, calm, intentness, patience, caution, safety in behaviour as well as sector-specific skills such as knowledge about matters and their composition and skills to use equipment. Creativity or innovation was connected with pathologist, horticulturalist, software designer and production designer. Mechatronics mechanic needs mainly manual skills. Students mainly pointed out ways of thinking and ways of working, however using different expressions. Students also focused more like on individual's characteristics in working.

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Evaluating scenarios which promote student`s science related career awareness–an Estonian experience in the MultiCo project.

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Abstract

Making science education and science-related careers attractive for young people is an ambitious goal, since it targets no less a goal than a drastic improvement in the scientific and technological literacy within our society, by giving value and enjoyment to science education learning. This study is examining the relevance of career related scenarios in the eyes of the students as an approach to raising awareness of science-related careers and from such an awareness, greater motivation to study science in school.

Emphasis on subject content-related teaching has caused gaps between students'/society needs and school science teaching. This has led to decreasing numbers of students choosing science-related careers and studies at the tertiary level (EC, 2010). Studies linked to the promotion of 21st century skills suggests there is a strong need to place more emphasis on interdisciplinary cross-curricula skills (PS, 2009). Promoting career awareness suggests that more attention is needed to the context associated with the teaching. This context can be society, or the concerns and issues within the society. However, it is not enough to introduce to students, new, updated developments in science isolated from its in technological uses in society, as students need to see its relevance in a societal sense and to have the opportunity to be actively involved in thinking and discussing and forming opinions. Student awareness about science-related careers is low. Research has shown also that student`s career awareness needs to be promoted throughout schooling, with the latest starting time being the beginning of lower secondary studies (Maltese &Tai, 2011).

In the frame of the MuliCO project, theoretical characteristics were worked out for the purpose of developing student perceive –relevance of the learning and science careers awareness inclusion through introductory scenarios. The scenario are thus intended to form a student intrinsically motivational start for teaching science/chemistry at the lower secondary level. The scenarios–constructs expressed in words, but which might have illustrations, or be expanded by cartoons, videos, power point slides, etc. and which cover issues with a global, yet local, reach related to energy, food production and health. Based on the initial developments, exemplary scenarios for chemistry learning would be introduced. In the study, student`s relevance was hypothetically seen as the reason for students perceiving interest, which, in turn, was expected to lead towards intrinsic motivation, positive attitudes and meaningful learning. To address such a hypothesis, an instrument for evaluating the scenarios was developed, grade 7 students from four schools, were asked to evaluate the scenarios. Importantly, at the grade 7 level, the majority of students were not able to separate "interesting" form essential, or important. The presentation explores the types of scenarios, the manner in which they are intended to raise career-awareness for grade 7 students and students association of these with a future career.

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3D printing for chemistry – how we do it conference theme: ICT in Chemistry Education

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Abstract

3D printing is new and prospective way for fabrication of visual teaching aids. Unfortunately, the process of 3D printing can be complicated by variety of factors which limit the number of printable 3D objects. With respect to that the contribution deals with design for 3D printing and 3D printing process of the selected teaching aids for chemistry and with investigation of the most effective procedures of 3D printing of the aids.

3D printing is a new and modern way for fabrication of three-dimensional objects tailored to our concepts and needs. There is a variety of 3D printing procedures, mostly they can be characterized by the term of Additive manufacturing (AM), which can be understood as any technology that build 3D objects by adding layer-upon-layer of material. Generally, 3D printing systems based on Fused deposition modelling (FDM) are mostly available. The models for 3D printers are usually formed in CAD (Computer aided design) systems by variety of ways. Although it seems that any model and/or object can be simply modelled and consequently fabricated by 3D printer, the 3D printing process is much more complicated with many rules and limitations. For example, the factors influencing the output and possibility of the printing are shape of the 3D object, quality of the prepared digital 3D models, various printing settings (thickness of layer, wall thickness, position of supports, …), technical aspects (e.g. stucks of plastics in nozzle), time necessary for printing and post-processing of the model etc. Despite the mentioned complications, the 3D printing seems to be very prospective procedure for fabrication of teaching aids which are not simply available in the market or they are expensive. With respect to chemistry education, the object can be any molecule, especially for teaching of stereochemistry and chemical structure themes, orbitals, 3D graphs or aids for customized laboratory courses (test-tube holders, various clips etc.). With respect to that, the contribution is focused on design of the selected teaching aids for 3D printing and on investigation of the most effective procedures of 3D printing of the teaching aids with respect to some parameters as price of the model, quality of the model, time necessary for printing and post-processing and application potential in education. The process of 3D printing of the selected objects is described from preparation of 3D model through various conversion procedures to CADs systems format, ab-initio design and preparation of model, printing settings and finalization of the printed object. Some models will also be presented.

Fig. 1: 3D printed object – protein

Fig. 2: 3D printed object – orbital d_{xy}

Triadic Dialog Interactions in Chemistry Learning Facebook Group

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One of the main models of discourse present in the classroom is the Triadic Dialog. According to Wells (1993), the Triadic Dialog accounts for more than 70% of total classroom interactions. Classically, Triadic Dialog begins with a question raised by the teacher, followed by a response of one of the students, and an ending of the discourse with the teacher's evaluation of the student's response (Initiation-Response-Evaluation, IRE). Wells reports that for most teachers there is no reason to adopt a different discourse model, and they will prefer this one at any given opportunity.

As a social network, Facebook facilitates group interactions between students and teachers and between student peers. In particular the Chemistry Learning Facebook Groups (CLFG) (Rap & Blonder, 2015) encourages students to talk about chemistry, to interact about chemistry, ask questions and learn chemistry.

Our main research goal was to describe and analyze the unique characteristics of Triadic Dialog discourse in the CLFG.

Population

The research population included 14 Chemistry teachers and their students who were members of the CLFGs. The research was conducted among 707 students (grade: 10th to 12th) majoring in chemistry. Students' participation in the groups was voluntary.

Analysis of learning interactions of the Triadic Dialoge kind

The basic unit of analysis was any concatenation of a Triadic Dialog observed in the CLFG. The following aspects were analyzed: Initiator of discourse, structure and content, and person ending the discourse. In addition, we evaluated whether the evaluation provided in the IRE cycle effectively terminated the learning discourse.

Results and Discussion

Most (90%) Triadic Dialog questions at the CLFGs were raised by the students, as oppose to the norm in the frontal class. In SNSs, such as Facebook, we find student-initiated discourse. It is apparent that a shift of power occurs from the teacher to the students. The CLFGs provide the students with the opportunity to receive immediate feedback to their questions, and real-time peer-review during homework or exam preparations, namely provides an opportunity to learn.

In 85% of the discourses the evaluation stage terminates the discussion. The evidence for students' learning is through their responses reflecting their understanding: "Like" "OK, got it!" or "Thanks". However, when something was unclear the students insisted on asking until they were answered. Furthermore, it is evident that questions raised by students on the CLFG reflect something that the student does not know and actively tries to understand, as oppose to teacher-initiated questions, which test students' knowledge. This finding shows that Triadic Dialog, which exists in social media differ from the classical model that is found at the classroom.

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Drama for Inclusion in Science: Recognising the Role of Artisan Input

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Abstract

Drama is used to present history and philosophy of chemical discovery, recognising artisan input.

Introduction

Braund (2015) stated 'Constructivist teaching methods such as using drama have been promoted as productive ways of learning, especially in science. Specifically, role plays, using given roles or simulated and improvised enactments, are claimed to improve learning of concepts, understanding the nature of science and appreciation of science's relationship with society. So far, theorisation of drama in learning, at least in science, has been lacking and no attempt has been made to integrate drama theory in science education with that of theatre. [Braund's]... article draws on the notion of the theatre as the 'empty space' to provide a new theoretical model acting as a lens through which drama activities used to teach science can be better understood and researched. There are many other similar articles concerning the contribution of drama to science education. The scenarios adopted directly pertinent to science education are twofold:

a) dramatic models such as using students to model particle movement in different phases;

b) historical narratives of eminent sciences, often to illustrate the nature of science.

It is relatively rare, if at all, to read accounts of the contribution of those other than eminent scientists who have made their contribution to scientific discovery. Nevertheless, it must be the case that they depended on the valuable inputs of artisans of significance. Dramatic licence afforded by the construction of plays provides opportunities to imagine what these inputs could have been, without necessarily implying historical accuracy. This paper provides an example of an input that is plausible and credible, involving a carpenter and a stonemason. Drama can also contribute to historical and philosophical understanding (see HIPST: http://hipst.eled.auth.gr/).

The HIPST project in the UK (detailed at http://hipst.eled.auth.gr/) used, as one of its tools, drama to focus on historical and philosophical aspects. The HIPST web site provides details of the challenges and successes of drama, especially the challenge of 'whiggishness', looking at the past through the knowledge lens of the present.

Context of the drama

Drawings of Lavoisier's laboratory provide many indications that it was not the work of one person, given its complexity. The Chemical Revolution of the late 18th century was based in large part on Lavoisier's new understanding of the chemical role of a gas —oxygen— in explaining combustion, respiration, and metallurgical processes like smelting. This advance in the theory of material change drew upon earlier work by other chemists, such as Joseph Priestley, who demonstrated that the air we breathe, previously thought to be uniform and not a kind of matter like solids or liquids, is in fact made up of several gases with different properties. Their theoretical advances eventually proved of great importance to modern society: many industrial processes require gases and their compounds and rely on a thorough understanding of the reactions that produce them. Lavoisier required a pneumatic trough to contain the gases he worked with, using mercury as the containing liquid since many of the gases were soluble in water. It contained a shelf, usually immersed, on which to stand the jars upside-down. Gases do not have an innate volume but only when trapped by the faces of solids or liquids. Lavoisier invited an artisan (carpenter) to build a trough from wood and filled it with mercury. In the morning, he found that the mercury had leaked out during the night as the wood contracted opening up the joints. He found another artisan (a stonemason) to make one from marble, and this did the trick. The play tells the story from the point of view of the carpenter, and incorporates history and philosophy into its telling. The paper provides pedagogical advice on use in classes aged 11-14 years old.

Conclusion

The paper will provide evidence of its success based on pupil feedback and project documentation.

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Sneaking the history of science through its images in science teacher education. The case of the pneumatic trough

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Abstract

This communication addresses the question of the appropriateness of historical images of science used as teaching resources to present the history of science to pre-service and in-service science teachers. The focus will be on the image of Joseph Priestley's pneumatic trough of 1775 as a guiding resource to promote discussion about different issues.

Science teachers are not expected to have enrolled as undergraduate students in a historical course during their university careers. For this reason, certain post-graduate courses of science teacher education intend to fill this educational gap including a number of sessions devoted to the history of science. In this context, it is not a minor issue to look for appropriate formats to present the history of science to pre-service and in-service science teachers.

This communication addresses the question of the appropriateness of historical images of science used as teaching resources. When discussing about images such as paintings, photographs, maps, tables, drawings, diagrams, formulas, etc. students are able to discover elements that can help themselves to generate and share explanations. The idea would be to use the history of science rather than to teach it, sneaking it by giving homeopathic doses through images. The image of Joseph Priestley's pneumatic trough of 1775 may be suitable as a guiding resource to promote discussion about issues such as the nature of the aerial state, the interaction between theory and apparatus design, or the constraints and risks of the parts and materials used in the making of apparatuses.

History of chemistry and nature of science: what do these mean to chemistry teachers

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The need of every person to understand the nature of science (NOS) in order to make decisions in a society highly influenced by developments in science and technology has been stressed in recent years. [1] The involving history and philosophy of science in the science classes is characterized as a good way for learning NOS and improving scientific literacy of students. Efforts for implementing history and philosophy of science in teaching practice cannot ignore: the perspectives of teachers, their beliefs, understanding of the main ideas and goals of teaching/learning and epistemological understanding. [2] The survey with 272 chemistry teachers from primary schools in Serbia was conducted during the realization of one in-service teacher training programme. The questionnaire used for the purpose of conducting this study contained four main parts: (I) questions related to the personal data of teachers (gender, age, years of service in education, the level of previous education, the presence of the courses of history of chemistry and philosophy of science in their previous education); (II) questions related to the views of the teachers on some features of NOS (for example: creativity in science, tentative nature of science) and about the importance of history and philosophy of science in science education; (III) questions related to the views of the teachers about the importance of history of chemistry in chemistry teaching for student's better understanding of chemistry; (IV) questions related to the ways in which teachers present science to students and the types and frequency of students' activities in classroom with potential to improve the level of their understanding of NOS. The questionnaire comprised closed-type questions (multiple choice questions and those with a Likert scale) and open-type questions, requiring the respondents to give appropriate information. The teachers answered to the questions anonymously. The obtained results showed that teachers recognize the potential of the history of chemistry contents to contribute to better student's understanding of chemistry. The teachers' answers showed that they are familiar with some features of NOS but they do not carry out a lot of the activities which provide possibilities to students to perceive NOS and learn about it. The results indicate the lack of courses from the history and philosophy of science during initial education of chemistry teachers. The difference in the acquired knowledge from the history of chemistry and philosophy of science during teachers' initial education do not make significant difference among their teaching practice. Regardless of whether teachers had these courses or not, they rarely use contents associated with the history of chemistry in the classroom.

This paper represents the result of working on the project "Theory and Practice of Science in Society: Multidisciplinary, Educational and Inter-generational Perspectives", Reg. No. 179048, the realisation of which is financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

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Towards relevant integrated chemistry education

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Abstract

Our aim is to understand integrated education (IE) from science teachers' perspective and to promote relevant integrated chemistry education. The initial findings on teachers' perceptions of IE are reported. Views are various and many do not see the relevance of IE to subject matter teaching.

This survey is a part of an ongoing design-based research. The aim is to understand integrated education (IE) from science teachers' perspective and to find relevant ways to support chemistry teachers' PCK in regards with implementing IE. Many studies (e.g. Brante & Brunosson, 2014; Bennett, Lubben & Hogarth, 2007; Cho, 2002; Lavonen & Laaksonen, 2009) have shown that context-based and integrated science education (ISE) can improve students' attitude, learning of science and enable holistic understanding of the complex contexts of real-life.

Relevance, regarded from different perspectives (e.g. teachers, students and the society), is an essential goal for IE. It is a multifaceted concept linked to interest and meaningfulness. One main barrier of implementing relevant ISE is teacher's beliefs and practices. (Gilbert, 2006; Jenkins & Pell, 2006; Stuckey, Hofstein, Mamlok-Naaman and Eilks, 2013) Existing research on implementing ISE in practice are sparse, especially if focusing on supporting teachers' pedagogical content knowledge (PCK) (Czerniak & Johnson, 2014).

The initial findings of Finnish science teachers' (N=101) perceptions on ISE are reported. Chemistry is taught by 63 of the teachers and mostly (over 70%) in secondary or upper secondary schools. The data was analyzed first by explorative factor analysis and followed by content analysis. The findings show that teachers' understanding of IE is various. Majority defined it as context-based and regarded relevance as an essential part of it, but some had no knowledge of the concept. Also present was a tendency to define IE as something separate from teaching subject matter knowledge. Less than one fourth of the chemistry teachers thought that pupils' good skills in subject matter is an essential goal for ISE. To disseminate ISE into chemistry teaching practices teachers need support with understanding and implementing ISE relevant to teaching chemistry subject matter.

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Students' Understanding of Heat and Temperature: A Cross-Age Study

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Due to their interaction with physical world and society, students begin to develop their understandings of heat and temperature before starting school (Clough & Driver, 1985). Although students learn about thermal phenomena in their science classes, students can still be resistant to change their particular alternative conceptions of heat and temperature across grade levels (Chu, Treagust, Yeo, & Zadnik, 2012). This study aimed to (a) compare Grade 8, Grade 10, and the first-year undergraduate students' understanding of heat and temperature, and (b) analyze students' alternative conceptions of heat and temperature across the different grade levels. Thus, a cross-sectional design was utilized in this study. Thermal Concept Evaluation (TCE) Test developed by Yeo and Zadnik (2001) was employed to a group of students from each grade level to assess their understanding of related concepts. Data were analyzed by using quantitative methods.

A one-way ANOVA results revealed a statistically significant difference across the mean scores of all three groups in terms of understanding heat and temperature concepts. In addition, students' alternative conceptions identified on the TCE test were categorized into four conceptual groups which were: (1) heat transfer and temperature changes, (2) boiling, (3) heat conductivity and equilibrium, and (4) freezing and melting (Chu et al., 2012). In ***heat transfer and temperature changes*** conceptual group, students among all grade levels (e.g., 56.7%; 43.7%; 40.7%, respectively) demonstrated the alternative conception that "temperature can be transferred from one body to another". Students from all grade levels demonstrated alternative conceptions in all items concerning ***boiling*** indicating that "the boiling point of water is 100^{o}C" (e.g., 51%; 48%; 29%, respectively), "the temperature at the boiling does not remain constant", and "steam above boiling water in a kettle is at a temperature greater than 100^{o}C". In all items of ***heat conductivity and equilibrium*** conceptual group, students from all grade levels had alternative conceptions which were: "metal ruler feels cooler than wooden one because metal is good radiator", "objects at different temperatures that are in contact with each other do not necessarily move towards the same temperature", "the amount of heat in an object depends on the material that the object is made up of", "hot and cold are different, not at opposite ends of a continuum", and "some materials are difficult to heat, they are more resistant to heating". Finally, in relation to ***freezing and melting*** conceptual group, students from all year levels (e.g., 46%; 42%; 35%, respectively) indicated an alternative conception that "water cannot be at 0^{o}C."

The findings from the study strongly urge instructors to take students' alternative conceptions into consideration and design effective instructions to support student learning of heat and temperature. The instruction should offer students opportunities to experience temperature changes and heat transfer at multiple levels of representation.

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The tip of the iceberg in organic chemistry classes

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Organic chemistry is a heavily information and structure-laden discipline, "[...] more than other sciences, understanding chemistry relies on making sense of the invisible and untouchable"[1] (Kozma and Russell, 1997, p. 949). We constantly make use of models to explain the imperceptible of chemical phenomena or chemical behavior, e.g., in terms of describing structure-property relationships and express these models with a highly symbolic language and various representations. A huge amount of problem-solving and reasoning in organic chemistry requires drawing and/or interpreting structural representations of chemical substances. The ability to interpret a given representation and go beyond the explicit image is thus one of the major skills to successfully perform in organic chemistry.

However, appropriately using the relevant chemical concepts to interpret the representation of a given structure or reaction seems not to be necessarily straightforward for students. Numerous studies described the fragmented nature of students' reasoning while reasoning with chemical representations, like reactions (DeArellano, 2014), the electron-pushing formalism (Bhattacharyya, 2014; Grove, 2012) or recognizing structure-property relationships (Anzovino, 2015; DeFever, 2015))

Beside various accounts of students problems less is known about what information students are actually processing when they need to draw connections between a representation, like an organic reaction and the chemical meaning that this reaction is meant to convey (Graulich, 2015). How do they connect perceptional "surface-level" attributes of a representation with "deep-level" implicit attributes?

We conducted a qualitative interview study to investigate the behavior of students enrolled in an organic chemistry course when engaged in various categorization tasks. A set of electrophilic addition reactions has been used in this study. The critical attributes a student chooses to make a category out of the given set of electrophilic additions reactions give an idea about how students process and store information about reactions. The attributes chosen are classified as surface- or deep-level related using the structure-mapping theory from Gentner and Markman (1997). The results from this study support the notion that students are very prone to the surface-level of representations and make sense of depicted reactions in a very minimalistic fashion. We could observe that this surface-level focus changed students' perception of organic chemistry reactions.

An ongoing paper-pencil study explores to what extent the surface focus influence students' similarity and reactivity comparisons of substitution reactions. The preliminary results provide us with additional evidences, that the surface-level is the primary anchor for students, which lead them to erroneously confound a structural similarity with a chemical reactivity.

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Organic Light Emitting Diodes - Implementing an innovative technology into chemistry classes

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Organic Light Emitting Diodes (OLEDs) are one of the most innovative research achievements of our time [1]. The light emission in OLEDs is based on special organic materials, which combine the properties of classical polymers with the electrical properties of inorganic semiconductors. These so called conjugated polymers can be synthesized via standardised chemical routes and processed easily (i.e. via printing methods). This new material class leads to innovative applications as flexible displays and opens the pathway to inexpensive roll-2-roll fabrication of electronics. OLEDs are no longer a vision; it is an inherent part of our everyday life, as we can find them already in current smartphones and curved-TVs. Moreover, in future, it is going to play a major role in our living environment.

One task of science classes is to enable students to understand the theoretical concepts lying behind innovative technologies they use in their everyday life. Thereby, they are able to communicate about these technologies, form their own opinion and become capable of making decisions. It is our aim to implement the OLED-topic into the curriculum of chemistry classes, for which experiments and didactical concepts have already been developed [2-4]. In this presentation, we will outline research steps, which offer valuable clues about how to implement this technology into chemistry classes. Furthermore, it is crucial to have all necessary materials for building OLED devices in schools. Hence, we will also present a didactical kit [5], which includes materials to build low cost OLEDs as well as organic photovoltaic cells (OPVs).

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A Comparative Study on Presentation of Le Châtelier's Principle (LCP) in High School Chemistry Textbooks in Spain and Turkey

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There is a large body of educational research articles (Quílez and Solaz, 1995; Quílez-Díaz and Quílez-Pardo, 2015) dealing with the inadequacy of Le Châtelier's principle (LCP) when predicting chemical equilibrium shifts. In this regard, science education literature has ended up considering LCP as an ambiguous and limited statement that can cause many problems as a didactical tool (Quílez and Sanjosé, 1996). Thus, some researchers have eloquently discussed on deleting it from the school chemistry curriculum (Quílez, 2004; Cheung, 2009). Hence, instead of using this prudentialintended universal, precise and flawless rule (in its many different educational formulations), there is a widespread recommendation to employ the equilibrium law and the van't Hoff equation to predict the direction in which a chemical equilibrium system will shift when it is disturbed (Katz, 1961; Quílez, 2006). However, it seems that LCP still plays a preponderant role in the chemistry curriculum, both at pre-university level and in first-year college chemistry.

Thus, our aim is to study to what extent these research studies have changed the way chemistry textbook authors deal with the evolution of chemical equilibria when they are disturbed. We will study if textbooks of high school chemistry still rely on LCP as the major predictive tool or if they have adopted other alternative criteria, such as the use of the quotient of reaction (Q) in order to compare its value to the one of the equilibrium constant (K) in isothermal perturbations or the analysis of the van't Hoff equation of the variation of K with temperature when studying these chemical equilibrium disturbances. We will concentrate our examination on two different contexts: Turkey and Spain in order to report if there is a general pattern to present the related concepts and to unveil possible singularities.

Chemical equilibrium is covered in 11th grade in chemistry course in Turkey and in 12th level in Spain. In Turkeyeach country all schools use the same mandatory chemistry curriculum. Preliminary analysis indicates that there are not significant differences in the way chemical equilibrium disturbances are examined, as both Spanish and Turkish chemistrythe textbooks still explains the factors that affect chemical equilibrium through LCP. without discussing it qualitatively Also, they normally do not mention any case in which LCP is limited. In addition, Q-K criteria has beenare stated but not used to estimate the shifts in chemical equilibrium. Moreover, the rate of forward and reverse reactions are explained but they are not interrelated with the chemical equilibrium. Finally, the possible effect of the addition of an inert gas hasis mentioned but superficially analized. but not discussed qualitatively.

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Conceptual and Inclusive Chemistry Learning – a contradiction

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Inclusive school systems are politically enacted and an ethical imperative (European Agency, 2012). How teachers are supposed to teach a certain subject inclusively is not common knowledge yet (Florian & Black-Hawkins, 2011). There are recommendations, but it is still a new field for systematic chemistry education research. One reason is, that the understanding of inclusion severely varies and that it depends a lot on the research context.

The project at hand follows a definition of inclusion of the UNESCO (2005) which seems to be compatible with teaching contexts. It claims inclusion as "a **process** of addressing and responding to the diversity of needs of all learners through increasing participation in learning, cultures and communities, and reducing exclusion within and from education. It involves changes and modifications in content, approaches, structures and strategies, with a common vision which covers all children of the appropriate age range and a conviction that it is the responsibility of the regular system to educate all children" (UNESCO, 2005, p. 13, original emph.). During the project the aim was to explore in a case study which strategies a chemistry teacher uses in different teaching settings to support chemistry learning of diverse students. It was also strived for to reconstruct what implicitly influenced her way of teaching. These two levels of analysis suggest following Documentary Method (Bohnsack, Pfaff & Weller, 2010). Data basis were about 20 videotaped chemistry lessons of two eighth grade chemistry classes, where the researcher acted as a participant observer. Video analysis is done applying Documentary Method to visual data (ibid.).

First, on a macro level of video analysis different teaching settings were identified to be contrasted with each other, e.g., teacher-led discourse and inquiry-based learning were observable (cp. Blanchard et al., 2010; Ødegaard & Klette, 2012). Then, on a micro level different scaffolding strategies were perceived and described during different teaching settings, for example, during teacher-led discourse the teacher explained abstract concepts by using phenomenological metaphors and gestures. However, only a minority of students could participate in this discourse in form of uttering their conceptions and responding to teacher's rather closed questions. During inquiry-based sessions all students could participate, but only during practical activities. When the teacher tried to relate the activities to abstract concepts of chemistry learning, only the same minority of students was involved.

It becomes evident and can be shown by selected examples how exclusive conceptual chemistry learning is. It was reconstructed in a research group how the teacher's actions are driven by the wish to allow for participation. This wish is, however, undermined by the strain to achieve a certain learning goal at the end of a lesson. Furthermore, the teacher seems to be convinced that students can only understand chemical concepts when she helps them visualize and deduct the concepts from her hints.

Whether inclusive chemistry lessons should involve conceptual and practical learning for all and how this could be enacted, shall be discussed after the presentation.

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Pre-service primary school teachers' understanding of chemical bond at the submicroscopic level

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Triple nature of chemical concepts is an important aspects that teachers should take into account when explaining abstract chemical concepts (Devetak and Glažar, 2014). Basic understanding of chemical bonding is fundamental and essential to the understanding of almost every topic in chemistry, but it is difficult to learn (Özmen, 2004) and students develop a wide range of misconceptions (Yayon, Mamlok–Naaman and Fortus, 2012). The influences of different independent variables such as formal reasoning abilities, situational interest, and students' learning activities are explored in this study. Because pre-service primary school teachers are not highly intrinsically motivated for learning chemistry (Juriševič et al., 2008) different teaching approaches (i.e. large classroom lectures upgraded by tablet PC presentations, web assignments for exercise and on-line test before mid-term exam) were used in teaching. The influence of these approaches on students' learning was also studied.

96 (88.5 % females, 11.5 % males) pre-service primary school teachers (19 years; SD=8 months) participated in the study. Data were anonymously collected using situational interest (SI) questionnaire, formal-reasoning abilities (TOLT) and Chemical Bond Knowledge (max 100 points): pre-Test prior to intervention (preCBKT), Test following the intervention (CBKT), post-test1; mid-term exam (post-CBKT1) and post-test2; two-month follow up (post-CBKT2). Students could also solve additional on-line assignments before taking the CBKT. Instruments' measuring characteristics were satisfactory. The data were statistically analyzed using the SPSS program.

A one-way repeated measures ANOVA was conducted to compare scores on the chemical bonds achievement tests; means represents percentages of scored points (preCBKT; M=32.2; SD=13.2, CBKT; M=53.0; SD=13.8, post-CBKT1; M=73.0; SD=12.6), and post-CBKT2 M=52.1; SD=22.0). Results show that students' knowledge about chemical bond concepts at the submicrolevel significantly change during the semester (Wilks' Lambda = .087, $F(3,77)$=268,01, $p \leq .000$). The influence of students' formal reasoning abilities diminishes after learning specific chemical bonding concepts. Correlations between students' situational interest and their achievements on knowledge tests are not significant. Students who did the web-assignment and on-line test and also did their work more successfully (scores at both web assignments were higher) achieve better understanding of chemical bond concepts (CBKT; M=54.3; SD=12.6). Because students' achievements drop after two month to the level just after the lecture (CBKT scores) it seems useful that the achievement scores would be taken from the students also after one year. This should reveal, if the chemical bond concepts were integrated in students' mental structure more successful after the university course than after the primary and secondary school chemistry.

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Is Avogadro number an irrational number?

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Abstract

The "amount of substance" has been one of the most discussed magnitudes in chemistry. Most part of the pupils, and also some teachers, have some misconceptions of these two concepts. Then, we should think about how we can correct these confusions but... what has it been its evolution? Which are these "confusions"? And why do they happen?

Development

The "amount of substance" has been recognised one of the basic magnitudes not long ago. However, it hasn't had the significance it deserves. That sentence is based on the blurred conception of its fundamental unit, the mole. It has been highlighted so many times in the chemical didactics.

In our research we want to expose that this ignorance about the magnitude "amount of substance" and the misuse of the "mole" has an important consequence. Students learn a poor atom model, because they accept its existence and its related definitions in a "non-chemical" way, disconnected of the chemical reactivity of the substances. We think that the equivalence between the mole and the "Avogadro Number (Na)" helps on it because the "mole – Na" becomes an atom counting method contrary to its primal meaning of "amount of chemical interaction".

We'll show in this communication the result of our analysis in two different ways:

1) The answers of a questionnaire about the magnitude and its fundamental unit (amount of substance – mole / Na). It was answered by a group of science teachers and we want to manifest their misconceptions.
2) The answers of a group of students. They constituted an optative discussion forum about the usually used analogy *"the mole is the dozen of the chemist"*.

We also analysed a couple of chemical textbooks searching how they explain the mole and the number of Avogadro.

Our results showed us that the sentence *"Na is a rational number according to mathematics, but it is a irrational number according to chemical didactics"*.

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Chemistry teachers' views of ChemistryLab Gadolin as a meaningful nonformal learning environment

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There is a need to promote chemistry teaching through meaningful nonformal learning environments. Earlier research shows that learning out of school increases students' motivation and interest in chemistry and also helps to develop teaching methods (Bell et al., 2009; Dillon et al., 2006; Orion & Hofstein, 1991). Most common challenges in chemistry teaching are weak connections between every-day-life and scientific knowledge (Hofstein & Kesner, 2006). Out of school learning environments reach authenticity which cannot be reached in schools. Non-formal learning environments can tackle these challenges (Bjornavold, 2000; Tolppanen et al., 2015).

The aim of this survey was to understand the meaningfulness of the student visits to ChemistryLab Gadolin (http://www.kemianluokka.fi) for the teachers. The study was the part of a design research (Edelson, 2002) project (a need analysis). Chemistry teachers (N=74) who visited the ChemistryLab Gadolin with their students, were asked about the reason, aim, learning outcomes and arrangement of the visit. Gadolin is a non-formal hands-on chemistry learning environment for all school levels in Department of Chemistry in University of Helsinki. It is free of charge. This survey was created and analysed based on previous chemistry learning environment studies. (eg. Aldridge et al., 2000; Dorman et al., 2006; Wong et al., 1997). Data was analysed by using content analysis.

New information about the meaning of the visits for the teachers were gained. The main reason for study visit was to raise student interest towards learning chemistry, and also to get information about future studies and occupation. Content of the visit related to curriculum and use of laboratory instruments which are unavailable in schools were also important matters for the teachers. The study visit acted as in-service training for the teachers. The development instrument of non-formal meaningful learning environment was created from the results. It contains the following factors: 1) participation in hands-on activities, 2) collaboration between students, 3) modern materials, 4) relevance for student, 5) inquiry, 6) ICT-based teaching and 7) support for the teacher.

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Fostering positive attitudes towards science and chemistry: What needs to change in the classroom?

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Researchers in a variety of countries have observed a trend of students' losing interest and enthusiasm for science and chemistry lessons as they progress through education (Archer et al., 2013; Salta, Gekos, Petsimeri, & Koulougliotis, 2012). This paper outlines a new investigation into the attitudes of students in Year 7-11 (ages 11-16) towards science and chemistry lessons which aimed to identify the factors that contribute towards negative attitudes through both qualitative and quantitative exploration. The study was conducted with the aim of supporting teachers in directly addressing problems in the delivery of lessons, thus reducing the likelihood of students rejecting the sciences as a possible area of further study.

A preliminary qualitative research phase involved the participation of 69 students from Years 7-11 in focus groups, in which they identified 11 major areas that correlated with a negative attitude towards science and chemistry lessons. An existing attitudinal scale (Attitudes towards Chemistry Lessons scale, (Cheung, 2009)) was modified to create an online survey that measured students' attitudes towards science and chemistry lessons. The modified survey also included additional questions which were designed to prompt respondents into identifying and qualitatively describing the reasons behind their answers. This helped to classify the factors that affected different types of students. The modified survey was taken by a total of 1654 students from a mixture of fee paying and non-fee paying schools in England.

Key findings based on the quantitative results of the modified ATLSCL were that students in Year 7 held the most favourable attitudes towards science and chemistry lessons, and that there were no statistically significant differences between the attitudes of male and female students. However, as the age of the students increased, the attitudes of female students towards both science and chemistry lessons became less positive compared with their male counterparts. Younger students also had a more positive attitude towards chemistry theory lessons than older students, whilst older students held more positive attitudes towards chemistry practical work. Female chemistry students indicated that they would be more engaged with chemistry lessons if the explanations of key topics were clearer, whereas male students preferred a more interactive learning style.

The quantitative data paired with the in-depth qualitative explanations collected via the survey have created a potentially valuable source of information for practitioners, which will allow them to adapt teaching styles and monitor progress to facilitate the development of positive attitudes towards science and chemistry lessons amongst their students.

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Evidences of the relationship between recreational chemistry and the increase of chemical vocations

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This project has been developed by researchers of the Departament of Chemistry of the Universitat de Girona, with the ultimate goal of fighting against the lack of interest by high school students in Chemical studies. The use of recreational chemistry along with explanations and demonstrations by University researchers in high school classrooms are the pillars of this project.

The experiments in recreational chemistry have been chosen from a pool of experiments which have been well tested in our laboratories. Some of them have been modified and adapted to be performed in a classroom environment. After some years of chemistry demonstrations in high schools, with the name of ***react… explode!***,[1] the project was improved as a result of a statistical study to evaluate the influence of these actions in the chemical vocations. The study has taken place in the area of influence of the Universitat de Girona, which means about 5000 km^2 and 800.000 people. The project was executed for two academic courses, at two different levels (secondary and baccalaureate), at 10 high schools (public, private and charter centers). After 5 years after such an initiative, we think that it is a good moment to analyze the data obtained and extract conclusions from the outcomes of this project.

Data obtained from considered high schools show that, after two years of chemical demonstrations, the number of students that chose chemistry as a subject in baccalaureate has increased, while the number of other science studies, on the contrary, decreased (Fig. 1).

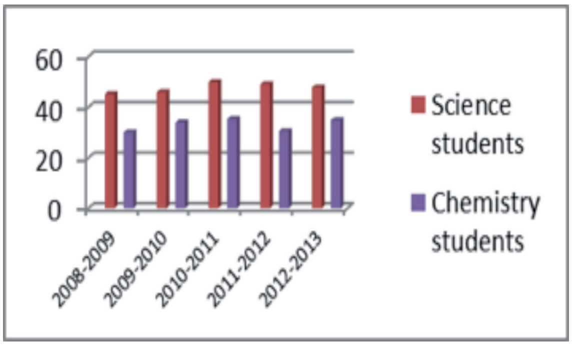

Fig. 1: number of students in first baccalaureate course from studied centers

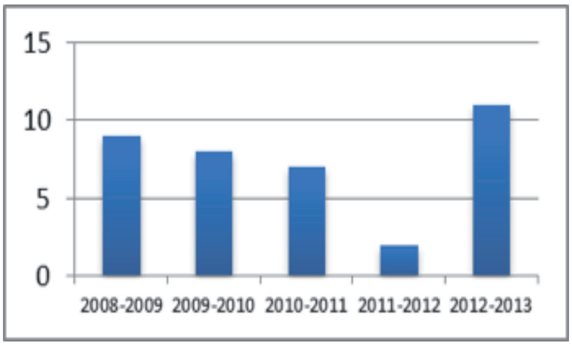

Fig. 2: number of students in first course of chemistry degree who come from studied centers

Furthermore, after four years of continued decrease in the number of students entering Chemical studies at UdG, in the year following our first activity in this project the number clearly increased, as shown in Fig. 2. More evidences will be shown in the final communication, regarding total number of students entering Chemical studies from all high schools whose referent university if UdG. Likewise, data for 2013/14 and 2014/15 will also be considered, even though we anticipate they will follow the ascending trend. We will also discuss whether the improvement in Chemical careers is due to our project, or also to the general program by the Departament of Chemistry and the International Year of Chemistry.

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The role of non-formal chemistry learning environments for curriculum design and innovation

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Over the past decades in many countries there has been a fast growing spread of non-formal education programmes with a major impact on the educational field. While formal learning in school remains the main educational institution in general, it is by far no longer the only facility where young people can learn systematically about natural phenomena in our world, about science and chemistry and about technology.

Non-formal settings provide chances for school students to deal with topics that are closely connected to their daily life since the non-formal activities are largely independent from governmental syllabi. New challenges like sustainable mobility can be aimed on by offering inquiry-experiments about the synthesis of biofuels, the function of hydrogen cars, or the properties and use of new materials. Furthermore, non-formal learning environments can also give students more freedom to organize their work in an autonomous and cooperative mode and also to discuss scientific and societal perspective behind any given issue.

This presentation reports a project of incorporating sustainability and environmental issues into chemistry education via non-formal educational project. Half-day events for secondary school students are implemented in a university laboratory environment. Based on a previous project on green and sustainable chemistry in non-formal chemistry learning (Garner, Hayes & Eilks, 2014), the new learning environments are thoroughly based on creative approaches to practical work and a differentiating model of science instruction (Affeldt et al., 2015). Creative instructions for inquiry-practical work encompass, e.g., comics, Facebook entries, Internet forums, or other approaches inspired by everyday life media. The learning environments allow for differentiation between higher achievers and students with disadvantaged educational biographies, e.g. from low socio-economic status areas, having a migration background, or limitations in their cognitive and linguistic abilities.

In the first year of the project more than 1000 students visited corresponding learning environments in the four participating German universities. Feedback from students and teachers emphasized positively the creative design of the learning materials and the systemic support of students with disadvantaged educational biographies. At the same time teachers learned about new topics and pedagogies, e.g. issues of chemistry's contribution to sustainability and alternative instructions for practical work. Thus, it can be suggested that the project also supports curriculum innovation in schools and continuous professional development of chemistry teachers.

Insights into the development of the non-formal learning environments, the design of innovative pedagogies and the varied teaching and learning materials, as well as findings from its implementation will be presented.

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Understanding the differences in the chemistry learning environments in New Zealand high schools and Universities.

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When students make the transition from high school to university they are faced with a raft of new experiences to assimilate. For many of them the transition to become independent learners provides the biggest challenge. However, most university academics are unaware of the differences between the high school and university learning environments or of the influence of high school assessment regimes. The First Year Experience[1] literature emphasises the importance of taking into account students' background, needs, experiences and patterns of study when designing a first year curriculum. This has prompted us to gather information to compare the student learning experience in chemistry in New Zealand high schools with that of their first year of university study. University students in their first year of study along with New Zealand high school teachers from a number of different schools have taken part in surveys and focus groups to ascertain both the nature of the learning opportunities and student perceptions of those which are most useful to them. The data will be used to inform future developments in the first year chemistry curriculum and to better prepare chemistry students for learning in the university environment.

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Interactive Whiteboards for teaching Chemistry and resulting tensions of their use

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Abstract

This research is aimed at characterising which tensions in the classroom arise from the use of Interactive Whiteboards (IWB) and how these tensions, and their impact in teaching Chemistry at secondary school level, can change in 2 academic courses.

IWB are one of the educational technologies with the highest penetration worldwide (Hennessy & London, 2013). The affordances of this everyday tool, are often referred to as enablers of educational change and improvement. However, research in this area shows that such connection is not unproblematic: Studies on science teachers' use of IWB have shown that, even when recognizing some possible benefits of using IWB in their lessons, they are unlikely to delve into how this technology can improve the teaching and learning process (Hennessy & London, 2013). Instead, the majority of teachers in those studies used IWB to support teacher-centred activities pursuing only motivational and work-enhancing purposes (European Commission, 2013). This situation has particular implications for Chemistry education, where the knowledge is often communicated through different modes of representation (such as images, text, videos…), expressed through different visual structures or at different conceptual level (such as macro-level, micro-level, sub-microscopic level and symbolic level) (Johnstone, 1991). Hence, it is necessary to understand what or which factors make possible to change pedagogies through IWB to make the most of this tool for teaching and learning Chemistry.

From this perspective, 10 secondary teachers were observed during their classes and subsequently interviewed. The sample was composed of participants with different years of teaching experience and ICT skills. After two academic courses, 6 of them were again observed and interviewed. Data gathered (mainly videos from the observations and audios from the interviews) were analysed with Atlas.ti 7. Cultural-historical Activity Theory (CHAT) (Engeström, Miettinen, & Punamäki, 1999) has been used in this study to interpret the contradictions or tensions between different elements of the Activity System and how they can evolve along time. This approach has been widely used to interpret changes in pedagogy of teachers with ICT associated with personal and contextual factors through a range of mediating artefacts such as can be the IWB.

Although the sample is reduced, the science-specific content of the research provides a diagnosis tool to assist teachers in understanding their own process of technology integration. Results, other implications and considerations will be discussed in the Congress.

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Learning higher-order thinking skills in General Chemistry: Using the "*ChemEd X Data*" website to teach students self-regulation

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In the *General Chemistry* curriculum there are several instances in which students are asked to judge between conflicting factors to decide an outcome. In fact, some have identified "the skill to judge between conflicting influences" as the essence of chemistry that all chemistry students should learn. To that aim I wrote the *ChemEd X Data* web interface[1] (http://chemdata.r.umn.edu/chemedXdata/). The main pedagogical objective of the website is to allow students to navigate, select and graphically represent data such as boiling and melting points, enthalpies of combustion and heat capacities for hundreds of molecules. By doing so, students can independently identify correlations between magnitudes, laws, and outliers. One of the merits of this tool is that it may help students recognize situations when conflicting influences play a role (e.g. molecular weight, shape and dipole effect on boiling point). Identifying conflicting influences empowers students with analytical skills that will lead them to higher-order thinking and self-regulated learning. Generally speaking, how factors may affect an outcome may be better understood using a structure-property relationship, which can be expressed as a linear algebraic relationship $Y = A\,X$

Where Y is the property, X are the structural factors involved and A is the set of substances. The word structure is not meant to be only geometric molecular structure, but also crystal, atomic or electronic.

Some curricular examples in a first semester General Chemistry course where students are asked to navigate between conflicting factors are the following:

"Y": Property to be predicted	*"X": Factors that may come into conflict*
Melting or boiling point of molecular solids	Intermolecular forces, shape and mass
Periodic table trends: atom size and ionization energy of elements.	Nuclear charge, electronic shielding and orbital size.
Ionic lattice energy of a crystalline solid	Cation and anion size and their charge
Electronic configuration of elements	Hund's rule and Aufbau principle
Heat capacity of molecules	Mass, number bonds and interactions.

In this presentation I will report some examples of the use of ChemEd X Data in class and how one can assess higher-order thinking. In particular, due to the integrated nature of our curriculum, one can avoid running a control group, and use other courses that students take concomitantly, and run a match-pair analysis. The analysis will be done on our in-house developed learning analytics tool, BoSCO[2].

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Mapping students' understanding of hydrogen bonding

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Learning chemistry requires understanding chemical phenomena involving interactions among the species at the particulate level and how they relate to the macroscopic level. Information and computer technologies provide opportunities with learning chemistry through visualizations including animations and the tools to develop animations.

In this research, a questionnaire was used to acquire insight on how preservice chemistry teachers model and visualize the interaction between two water molecules approaching each other. The questionnaire contained draw-explain-compare tasks. Moreover, the dynamic nature of the formation of a water dimer was highlighted by students' own animations. Finally, an animation created by a molecular modeling program was used by the students to reflect upon their conceptions.

This qualitative study reveals diverse ways to understand hydrogen bonding and to model the interaction between two water molecules. The comparison of the storyboards drawn and the animations prepared indicate that animations provide additional information of students' conceptions. Students' drawings, animations and interviews give a more profound view of students' understanding of hydrogen bonding.

Tailoring e-Learning Environment for Chemistry Education

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There has been great interest in e-learning methods in the field of chemistry. A large number of e-learning tools and teaching materials are available to teachers and students to assist learning. The role of an e-learning environment can vary from static material storage to interactive learning environment. The key questions in the use of e-learning environments are how these environments promote learning and what kind of contents would promote it the best.

The development of first year lecture courses in chemistry has greatly enhanced the significance of e-learning methods at the Department of Chemistry at the University of Jyväskylä during recent years. Today, blended learning methods are utilized in our chemistry courses. In an asynchronous e-learning approach learning is a combination of conventional face-to-face (lectures and tutoring) and computer-mediated (pre-assignments and exercises) activities. Using this approach has led to reallocation of teaching resources, which has reduced the role of passive learning in the courses. In contrast, the role of active learning has increased with the aid of the e-learning environment. Course statistics show, that pre-assignments in the e-learning environment have increased the students' activity on the course. Conventionally, our exercises have been typical textbook questions, that are transferred to the e-learning environment and equipped with an automatic feedback system.

In the present study we investigate students' perceptions of exercises containing simulations and videos of chemical experiments. Students were advised to do observations from the videos and to answer questions based on their observations. Simulations were used to show, for example, how graphical data analysis can be done. Students' perceptions were compared with their perceptions of conventional exercises. Students rated exercises containing videos and animations more useful than conventional exercises, but at the same time students criticized the quality and usage of videos and simulations. Even though videos and simulations were more highly rated, no increase in the course exam performance was found. This result is in agreement with previous research results, which show that the increased interactivity of e-learning increases the students' motivation, but does not have a noticeable effect on course performance.[1]

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Informing Teaching Practices by Investigating Undergraduate Chemistry Students' Online Homework Usage

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With the amount of data available through an online homework system about students' study habits, it stands to reason that such systems can be used to inform teaching practices. A study was conducted to see how student usage of an online chemistry homework system, Online Web-based Learning (OWL) correlated with student success in a general chemistry course. Online chemistry homework activity was examined for first-year students taking general chemistry at a mid-size, private university. The six different chemistry question sets examined were: bond properties; standard molar enthalpy; electronegativity; Lewis dot structures; calorimetry; and stoichiometry. Students' OWL activity was then correlated with their exam grades and their final course grades. Results showed that higher average time spent per question correlated positively with student success as measured by final grades. However, multiple attempts per question correlated negatively with student success. A multiple linear regression model and other guidelines are presented for instructors' use in identifying chemistry topics where students may need additional interventions to improve their understanding.

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Science Teachers' Experiences about Guiding Students along the Development of an Interactive Science Exhibition Artifacts

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Short Abstract

The purpose of this study was to capture and describe the experiences of science teachers guiding students along the development of an interactive science exhibition artifact integrating Responsible Research and Innovation (RRI) and cutting-edge science topics. Participants are 6 science teachers working at elementary and secondary schools.

Long Abstract

Exhibition is "a comprehensive grouping of all elements that form a complete public presentation of collections and information for the public use" (Dean, 1996, p.3). McLean (1993) defines interactive exhibition as "those in which visitors can conduct activities, gather evidence, select opinions, form conclusion, test skills, provide input, and actually alter a situation based on input" (p.93). This definition is adopted, which involves mental interaction besides the physical one, in this study. Exhibitions on art or history are the typical themes of student-curated exhibitions whereas the ones focusing on science are less frequent (Kampschulte & Parchman, 2015). Transforming related units of facts about science, individual knowledge and skills into a synthesized coherent whole as a science exhibition project involves the fundamental aspects of doing science such as planning, critical thinking, collaborating and using creativity, and therefore is a fruitful experience for students.

Doing responsible research and innovation (RRI) is a rapidly developing phenomenon in science as well as in science education (Von Schomberg, 2013). Therefore, science exhibitions integrating RRI are a kind of platforms at where students and visitors have a chance to ask questions and discuss on risks and benefits of related science topics. EU-funded project IRRESISTIBLE, involves science teachers and students in the implementation of a module about a cutting-edge science topic integrating inquiry and RRI, 4-week period of development of an interactive exhibition product and student-created exhibition in schools and a science center. The participants of this study are 6 science teachers from elementary and secondary schools in Istanbul, Turkey. Before guiding the development of interactive exhibit products, teachers participated in a workshop, at which the concept of interactive exhibition is introduced, 2 videos of some science exhibition events are shown, and the selected artifacts from the previous exhibition were demonstrated.

The purpose of this study was to capture and describe the experiences of science teachers guiding students along the development of an interactive science exhibition artifact integrating RRI and cutting-edge science topics. This is a case study at which qualitative data collection methods are used. Pre and post semi-structured interviews with 6 science teachers, field notes and video recordings of workshop for teachers about interactive exhibitions and 4 week-exhibition product development process were analyzed, coded and emerging categories were determined. Preliminary results showed that teachers have limited or no knowledge about what an interactive exhibition is. They need support about what kind of products, projects or artifacts can be developed, how RRI can be integrated into an exhibition product interactively and they have concerns about time management.

Key words: Interactive exhibitions, Student-created artifacts, Teachers' experiences of guiding students in preparing interactive exhibits

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Experimenting with ice: suggestions for active inquiry-based learning of science and STEM competences

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In recent years it has been fostered the need to promote an active learning of STEM competences. It is considered as very important to encourage student for the discussion about experiments made by them contextualized around substances of everyday life. In this paper several experimental studies developed with students (15 to 18 years old) are shown.

Essentially, the work has been to present to students two questions that had to be solved by experiments carried out by cooperative work. Briefly, these issues are:

1. Argue where will melt faster an ice cube left in water or in saturated salt water.
2. Try to get an ice cube as transparent as possible by freezing water in your refrigerator.

Regarding the first point, it is carried out from a previous reasoning and a starting experiment in which two similar ice cubes are placed in two glasses, one with water and one with saturated NaCl water solution. Students discover that, contrary to what most people think, the rate of melting ice is greater in the first medium. Then, it is suggested to them to assess other variables for testing possible hypotheses: agitation, concentrations of salt, other solutes (such as sugar), etc. After a process of discussion, a key demonstration is to show how can be viewed the convective currents generated when ice melts, reasoning how this effect is the most significant in explaining the observed behaviour. This activity explain in part the thermohaline circulation in the oceans (with influence on climate).

Regarding the second point it is initially discussed with the students if ice cubes made in the refrigerator are perfectly transparent. Noting that they are often frozen with a cloudy aspect students are asked to discuss why the ice looks like this and they are suggested to prepare ice cubes as transparent as possible. This optical property can be improved considering mainly three variables (salts dissolved in water, dissolved air, and freezing rate).

From these experiences may arise other complementary, such as the study of the behaviour of an ice cube in other current liquids like ethanol or cooking oil.

Possibilities for Chemistry education provided by Scientix and STEM Alliance

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Abstract:

There is a continuous need to improve the skills of teachers engaged in teaching chemistry, so that students may be enabled to make contributions when approaching important current affairs. The presentation focuses on the possibilities for Chemistry education provided by two European projects, Scientix and STEM Alliance.

1. Scientix- possibilities for Chemistry education

Scientix, the community for STEM education in Europe, supported by the EU within the 7th Framework Programme, was created to promote sharing and exchange of good teaching practice and learning materials in STEM education. Scientix offers teachers of chemistry of all levels, methods for teaching and learning chemistry through a set of online educational resources, webinars (online presentations of up to 1.5 hours on topics related to STEM education and addressed to STEM teachers) as well as Moodle courses (short online courses addressing different tools and methods that will support STEM teachers in their classes). Scientix resource repository (http://www.scientix.eu/web/guest/resources) collects the online educational resources from science education projects who have benefitted from public (EU, national or regional) funding. So far, the Scientix repository accumulated over 200 online resources related to Chemsitry Education which are made available for translation in 35 different languages through the "translation on demand" service. Moreover, Moodle courses such us Chemistry Experiments, Radioactivity, etc can be used by chemistry teachers from all across Europe. All these opportunities have a direct effect on the success of the implementation of any educational innovation.

1. STEM Alliance – possibilities for Chemistry education

STEM Alliance is an international initiative that facilitates the relationship between education and industry in order to improve STEM education and inspire young people to pursue careers in those fields. The project provides students and teachers alike with a pool of high quality educational resources that make STEM subjects more accessible and engaging. The initiative is supported by ten major industries, including Chemical industry partners as for example EPCA, Shell, etc. These partners are offering a couple of educational resources such us movies (ie. "Chemistry: All about you", "Science: Where can it take you?" & "Petro and Chemistry: Partnership for a Better Life"), teachers' guidelines, various education activities, whilst Chats with Chemical company's experts and school students across Europe are being organized in the framework of STEM Alliance initiative.

Inquiry-based Learning as a Predictor of Adolescents' Science-related Career Aspiration

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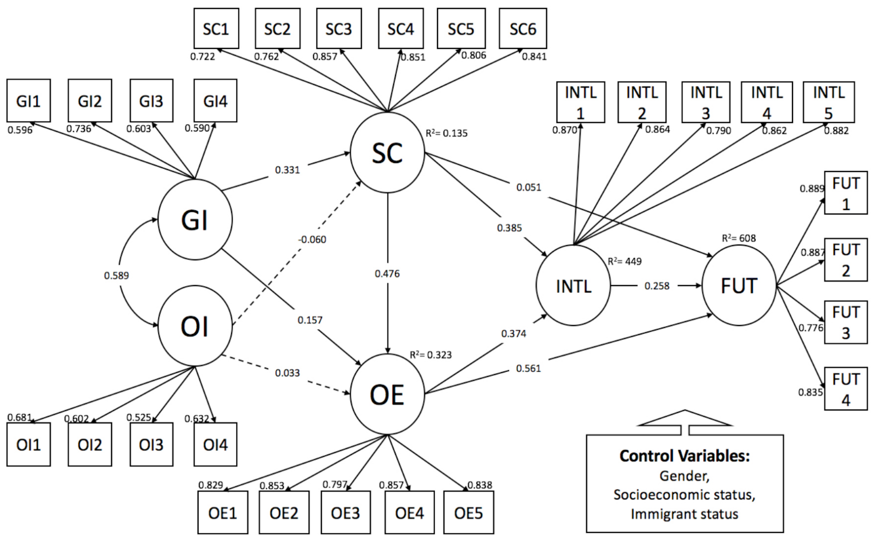
Abstract

Many researches investigated the effects of inquiry-based learning on students' attitude towards science and future involvement in science field, but few of them conducted in-depth researches including young learners' socio-cognitive background to explore mechanisms which explain how inquiry experiences influence on career choices. Hence, the aim of this study was to investigate in what way and to what extent the inquiry learning experiences in school science affect students' future career orientation in the context of socio-cognitive mechanisms based on socio cognitive career theory (SCCT; Lent, Brown, & Hackett, 1994). For the purpose, a sample of Finland 15-year-olds students (N=4714) participated in the PISA 2006 (OECD, 2007) was analyzed by structural equation modeling (SEM) with the hypothesized Inquiry-SCCT model. The results of the study showed that guided inquiry learning experiences indicated as a strong positive predictor for the students' career aspiration mediated by self-efficacy, outcome expectations, and interest in learning science. On the other hand, open inquiry learning experiences indicated small and insignificant effect on students' future career orientation. In addition, no gender differences were found in the model in terms of students' career choices. The result suggest that the students' science related career aspiration was largely explained by this model (60.8%) and emphasize the pivotal role of inquiry learning experiences in school science.



Note. GI: guided-inquiry, OI: open-inquiry, SC: self-concept, OE: outcome expectations, INTL: interest in learning science, FUT: future career goal, Model Fit: Chi-square= 3831.532 (.000), df= 435, CFI= .960, TLI= .955, SRMR= .034, RMSEA= .041 (90% C.I.= .040, .042)

Figure 1. Path analysis of hypothesized Inquiry-SCCT

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Chemistry teachers' training as the most important condition for ibse teaching

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Abstract

Faculty of Science of Charles University in Prague has been preparing and realizing training courses for primary and secondary school science teachers for many years now and nowadays we focus on educating teachers in implementing the IBSE approach in their school practice, so the teachers are not afraid to use it and their teaching is better.

The problems which are recently happening in the field of chemistry education are known enough – low interest of students in chemistry, not understanding chemical knowledge, only formal knowledge of chemistry without a connection to practice and everyday life etc. Innovations in the content of teaching, new teaching tools (e.g. using ICT) or approaches like IBSE will be effective only when the teachers accept them and use them in their teaching. Because of these reasons institutions in the Czech Republic like the Ministry of education and universities educating teachers engage themselves in a system of further training of teachers and increasing their qualifications.

Faculty of Science of Charles University in Prague also engages itself with this issue and has a lot of experience with it. Further education trainings which we prepare and realize with teachers are always focused on current topics; nowadays mostly on implementing IBSE into teaching. We realize that for this to apply in a given country, at least four basic conditions must be satisfied. It is clear that the valid curricular documents must create space for such teaching, and simultaneously, there must be valid themes for it in the individual subjects; the students must be able to accept this way of teaching, and most importantly, the teachers must be able and willing to teach in such way.

Because of this, the Faculty of Science of Charles University in Prague has now been including IBSE approach in teaching of chemistry into the pre-service and in-service teachers' studies for several years. The main goal of this type of education is the simulation of the student's role by the teacher and the personal experience connected with successful inquiry. As the questionnaire surveys show, most of the teachers have heard about the new approach, but they hardly ever encountered it and so they are more or less worried about it. For this reason, IBSE seminars should dissipate these worries and convince the teachers that using this approach for chemistry teaching at lower and upper secondary schools is both useful and necessary.

Acknowledgments: Financial support of the 7th FP EU TEMI (No 321403) project is gratefully acknowledged.

Education through science as an approach to make chemistry education relevant in the eyes of students

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Abstract

It is clear from many studies that educators, particularly teachers, have not been able to reduce an alarming decline in students' interest in science education. A recent study among Estonian gymnasium students confirms that problem solving, decision making, creativity and communication skills are little promoted in chemistry classes.

Europe needs educated persons who have scientific competences to be able to function in the modern world to meet challenges related to developments in science, medicine, economic growth etc. (EC, 2004). It has been recognized that science (chemistry) education at school has narrowly focused on the subject content, building on conceptualisations from a past era. As a consequence, students tend to end up equipped with narrowly oriented declarative knowledge, often in isolated areas of science, leading to a lack of skills needed for everyday life. Gymnasium students welcome working in areas which demand creative and critical thinking, high responsibility and good communication skills. We are well aware that, in general, students have little interest in topics that are perceived to be irrelevant to their lives, or career aspirations. A more interdisciplinary approach is needed, related to the real world, non-routine problem solving, adaptability and self-development (NRC, 2010; Holbrook & Rannikmäe, 2007). The goal is to enhance students' intrinsic motivation and promote the students' self-determination. To enhance such learning, a 3-stage approach can be implemented in chemistry classes, described as contextualization (***learning within a meaningful context***), followed by de-contextualization (***learning in an unfamiliar context in chemistry),*** leading to re-contextualization (***chemistry related learning is incorporated in a meaningful new context***) (Holbrook & Rannikmäe, 2010). The effectiveness of this approach is discussed in terms of student`s attitudes towards learning chemistry and self evaluation of skills promoted through the above mentioned stages.

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Teachers' Misconceptions about Reaction Rate and Acid-Base Chemistry

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Type of presentation: oral presentation

Abstract:

The importance of research on misconceptions about chemical reaction rate and acid-base chemistry is well recognized by educators. However, in the past, chemistry educators' interest has centered on students' misconceptions and has neglected teachers' misconceptions. It is critically important to investigate teachers' misconceptions about chemical reaction rate and acid-base chemistry because teachers cannot help their students understand what they themselves do not understand. This paper reports on how data were collected from a sample of Hong Kong pre-service and in-service secondary school chemistry teachers (N = 30) through a written test and individual interviews using the think-aloud technique. Results showed that the teachers held a number of misconceptions about chemical reaction rate and acid-base chemistry. For example, most of the 30 teachers held the misconception that the concentration of hydrogen ions in 1 M sulfuric acid is twice that in 1M hydrochloric acid. Several teachers also thought that when hydrochloric acid reacts with copper(II) carbonate, the balanced chemical equation can correctly show the total number of reactant particles that must collide in the rate-determining step of the reaction. The significance and implications of these findings for the professional development chemistry teachers in secondary school are discussed.

(Re)construction of students' conceptions about chemical equilibrium by peer-led team learning

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This paper describes the construction of scientifically acceptable conceptions of high school students about chemical equilibrium during a PLTL workshop. It provides a set of tasks designed for team problem solving under the guidance of a peer-leader. These tasks supported deepening of the correct students' conceptions or modification of their alternatives.

One of many requirements placed on the educational process at high schools is to encourage the construction of correct students' ideas on the concept of chemical equilibrium. However, given the complexity of this concept, it becomes real challenge for teachers to create conditions for students that will lead to its meaningful acquirement. One option is to implement PLTL workshops. We conducted such workshop in a selected Slovak high school in the following three steps:

1) Insertion of a PLTL workshop in chemistry classes. In order to uphold the original ideas of the authors as closely as possible, we have focused our PLTL attention to future high school graduates, who were attending two-hour chemistry seminars.
2) For the selected sample of students we created a worksheet with the tasks, which encouraged mutual cooperation and discussion among team members and this way affected their higher order thinking skills, which are essential for problem solving [1]. Worksheet integrates:
   - Task 1 (derived from [2]) requires students' modelling of the course of chemical reaction $A \rightleftharpoons B$ with the same conversion of the particles A to particles B and of the particles B back to the particles A in every step (10 % in one second of the reaction time). Based on the data (recorded in a table) students subsequently transfer the individual values in a concentration vs. time graph and reaction rate vs. time graph.
   - Task 2 (inspired by [3]) again involves chemical reaction $A \rightleftharpoons B$. This time students should model its progress on the basis of known values of the rate constants $\boldsymbol{k}_1 = ½$ and $\boldsymbol{k}_{-1} = {}^1/_4$.

Before dealing with individual problems and solving them immediately after that, students introduced their actual concepts of "chemical equilibrium", which enabled mutual confrontation of students' different ideas and ultimately created the desired conclusion.

3) The individual tasks were solved by students clustered in 5 to 6–member team, which was managed by a leader – selected from among the students who had a thorough knowledge of the concept and communication and leadership skills at the same time. The role of pre-trained leader was to govern the course of the workshop and encourage the students to be actively involved in solution [1].

The accuracy of the acquirement of the concept of "chemical equilibrium" by students who attended PLTL workshop was verified by a subsequent problem solving tasks and concept maps. The results show that PLTL seems to be a suitable instrument for deepening the correct ideas or even to modify the students' alternative ideas about this process.

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Everyday analogies to understand the concept of aromaticity

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There are concepts in Chemistry which are difficult to master not only because they involve a high degree of mathematics or abstraction, but because they are not directly related to everyday experience. The meaning of Entropy, for instance, is much more difficult to understand that the meaning of Energy.

We are involved in teaching and disseminating ideas about key concepts in Chemistry and Science that are not easy to grasp but are relevant enough for high school and university Science students and even general Citizens. Entropy itself, the principles of Quantum Mechanics, Quantum Entanglement, cryptography, or DNA replication, expression and repair are concepts that we use to teach and disseminate with analogies.

We have been involved in the last years in the research of chemical aromaticity, both in trying to fully assess it, but also in the characterization of a wealth of molecules exhibiting different types of aromaticity. This concept can be traced back to the final years of the 19th century (a); indeed, benzene is the prototype molecule showing aromaticity, but there are many others showing other less well known types of additional energy stabilization by ring formation of special atomic arrangement. For example, we have been lately involved in the study of aromaticity of octahedral systems formed by 1st- and 2nd-row elements. Two of us participated in a review on evaluating aromaticity by computational procedures (b).

Here we will show how we use analogies to explain the concept of aromaticity. Indeed, first we need to address the concept of electron density: this is achieved by relating Bader's Atoms-in-molecules Theory to City population density in a regional environment. Chemical bonds between atoms are related to the density of cars travelling along freeways connecting cities (i.e., atoms). Aromaticity is then connected to the additional loss of traffic congestion when cities are interconnected and form a ring, like in benzene or atomic clusters.

In this communication we will also show how we use communication techniques like magic or storytelling to improve teaching and disseminating. And indeed, we will pinpoint that by thinking about the best way to communicate the concept of aromaticity, we are actually understanding it better – thus interconnecting teaching and research.

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Enhancing teacher learning using solo taxonomy

Päivi Tomperi & Maija Aksela
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SOLO taxonomy helped teachers to comprehend inquiry by providing a theoretical framework for analyzing and modifying written instructions. New learning material, sharing of ideas and enactment of created new material in class lead to development of pedagogical content knowledge (PCK) of teachers' according to interview after training.

Research-based training course on the practical chemistry instruction at the upper secondary level used SOLO (**S**tructure of the **O**bserved **L**earning **O**utcome) taxonomy (Biggs & Collis, 1982) as a tool to enhance teacher learning of inquiry-based approach. SOLO taxonomy increased teacher's awareness of how written instructions correspond to student performance in the laboratory task at hand. Research proved that the structure for the written instruction can be described qualitatively at five hierarchical levels with increasing difficulty according to SOLO taxonomy.

Information about teachers' professional development using SOLO taxonomy was obtained in the design process of an eight-phase design research project (Edelson, 2002) which employed qualitative research methods of observation, survey and interview. The data was analyzed using content analysis. During professional development chemistry teachers analyzed and selected laboratory tasks mainly from chemistry course books and modified them into inquiry-based tasks using SOLO taxonomy. Teachers practiced inquiry-based teaching methods at school and experienced how the modified instructions supported student learning. Research-based training model to promote inquiry aimed at expanding teacher's role as a dispenser of knowledge to a researcher of one's own work and a learner (Tomperi & Aksela, 2014). The development of learning material and interaction-based sharing of ideas together with enactment of created new material in class lead to development of pedagogical content knowledge (PCK) of teachers' according to interview after training which is in line with the recent results of Coenders & Terlouw (2015). According to research results teachers need training models of various durations. If teacher's view of learning is congruous with the inquiry-based approach, she/he can begin to practice the implementation of inquiry as an assimilation process during short training. The accommodation process is slower requiring teacher guidance and support.

SOLO taxonomy supported teachers' professional development in many ways: for example it worked as a tool in designing and modifying written instructions, motivated teachers to develop their practices, increased teachers' ownership to created new written instructions, supported teachers' understanding of inquiry and acted as a model for higher-order thinking skills.

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Welcome-Science' – Introrduction for Refugee–children in language and science

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The increasing numbers of refugees, entering Germany in the last two years need to be integrated into German culture and language more than was done for those who came in the 1960ìes and 90ìès. In particular the children of these refugees need support to enable them to integrate successfully into the German school system from the beginng.

An innovative approach in getting these children interested in learning the German language and introducing them into science at the same time is ‚Welcome Science'. This programme has been developed by the chemistry-didactic department of Bielefeld University supported by the Doris-Wolff Foundation and started in September 2015.

Central element of the ‚Welcome Science' Programme is the method of storytelling and the solution of ‚problem' by solving a chemical or physical experiment.

Around 30 chemistry teacher students visit refugee homes, or special classes for the newly arrived refugee children (aged 6 to 15) once a week. There are currently 180 children in the programme. The focus is on doing simple hands-on chemistry experiments backed up by explanation.

The students work in pairs and report on their individual experience and especially their impressions after each visit. This form of feedback is essential in forming an impression of the development of each child.

The most responsive children are then given the opportunity to follow a more intensive programme in the University laboratories and neighbouring science museums.

The award of a certificate after successful completion of the programme should give them wider opportunities for employment later on and strengten their selfconfidence.

Assessing students' progress in the virtual lab using trace files and rule-based analysis

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Abstract

The work done by a student in the ChemCollective virtual laboratory can easily be traced to a log file. These files can then by analyzed to automatically extract relevant information about the students' problem solving process.

Communication

The ChemCollective virtual laboratory is a well-known computer simulation of an aqueous chemistry laboratory. It is programmed in Java and can be run either online or as an offline application.

A less known feature of this virtual laboratory is its capability for tracing the students work into an XML log file that includes every action the student did when solving a problem in the simulation.

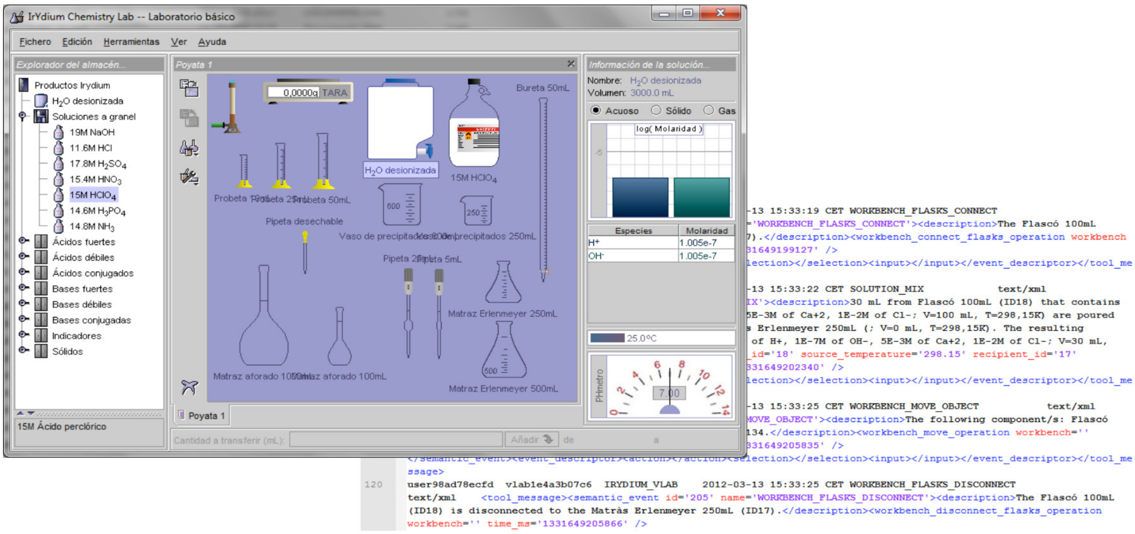

Figure 1. Screenshot of the ChemCollective virtual laboratory and a trace file.

This trace file can then be automatically analyzed to get relevant insights that could help to assess not only the students' results but how they progressed to solve a specific task. This approach, which consists in searching for relevant information in the trace files, can also help to identify common errors and individual difficulties.

Examples of this approach for a stoichiometry problem and a solution preparation problem will be discussed.

Exploring efficiency of systemically-oriented instruction in chemistry classroom: the 3-dimensional approach

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The efficiency of instructional methods is typically evaluated by comparing differences in students' test performances. Such performance-based measures alone are not sensitive enough, and should be complemented with othewr variables. According to this, the aim of our study was to investigate the efficiency of systemically-oriented instruction on one chemistry topic: Amino acids, by applying 3-dimensional approach.

With the aim of our study, an experiment with two parallel groups was conducted, including 159 forth-grade students (18-19 years old) from two high schools from Novi Sad, Serbia. During the second semester of 2013/2014 school year, the experimental group students (N = 84) were taught by applying specifically designed systemic synthesis questions, [SSynQs], which have been introduced by Fahmy and Lagowski (2014). On the other hand, the control group students (N = 75) received a traditionally designed instruction. In the first point of our study the learning mental effort was measured by using seven-point Likert scale on both experimental and control classes. In addition to this variable, test performance and test mental effort were also considered to calculate 3-dimensional efficiency of instructional conditions proposed by Tuovinen and Paas (2004).

As predicted, the students receiving systemically-oriented instruction scored significantly higher on the final written test than students from the control group. These findings were followed by experimental group students' lower levels of mental effort, reported on final testing. However, it was found that systemically-oriented instruction caused higher learning mental effort than traditional instruction. Namely, experimental group students invested relatively high effort in order to organize chemical concepts into the complex cognitive schemas on a meaningful way. This further contributed to the fact that the z-scores combination of mentioned three variables resulted in high, positive overall efficiency of systemically-oriented instruction (E = 0.202), and low, negative efficiency for traditional instructional method (E = -0.264). Implications for further research could be observed in adding some other variables in the 3-dimensional model, such as students' motivation, or time-on-tasks.

Acknowledgement. This work has been supported by the Ministry of Education, Science, and Technological Development of the Republic of Serbia, under Grant No. 179010.

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Zero chemistry mooc: building bridges towards university

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For the last 10 years the chemistry department of the University of Girona has invested a lot of effort to bring closer chemistry to high school students, creating bridges between the two worlds using different activities. Every year students at the Science faculty arrive with different level of chemistry, so the design of a course with the minimum level required at any scientific career had become an important objective for the Chemistry Department. Càtedra de Cultura Científica I Comunicació Digital had been involved in different MOOC design and deliver, being a good partner for the present project.[1]

Two main objectives are reached with this Massive Online Open Course (MOOC). First one will be focused in adapting and improving basic chemistry concepts, which is based in the idea of teaching the minimum knowledge about chemistry for attending scientific careers. This course will be deliver in June, within the UCatX.cat platform,[2] reaching, at least, all Catalan spoken students. But not only high school students will be the users of the present MOOC, also people who is interested in basic knowledge about chemistry. So this is also a bridge to the society.

A second important goal of Zero Chemistry MOOC is building a tool (a course) to help students and professors to interact each other, not only between them but also within them (students helping students). All the online material will be design as small knowledge pills, so they can be taken any of them when they are needed.

Building MOOCs, in that case a Zero Chemistry MOOC, can be really very expensive (talking about time and energy). C4D is involved in a Erasmus+ project with the main objective of building low-cost MOOCs,[3] not related to money, but to energy and time spent in its design. Following this idea, previous project on recording videos related to High School chemistry, "UAu Això és Química" will be part of the educational resources.

Zero Chemistry MOOC is going to be a very useful tool to bring Chemistry to high school students as well as general society, building bridges between them and University.

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[1] Info from @c4dudg: http://c4d.udg.edu
[2] UcatX.cat
[3] www.moocs4all.Eu
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Developing and implementing protocols in quality assurance to enhance educational development in tertiary chemistry education

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Introduction

Due to changes in national law, Universities in the Netherlands are required to follow strict regulations regarding quality assurance of educational programmes. Usually, these regulations lead to more paperwork for staff members. However, it seldom results in better education. At the Faculty of Mathematics and Natural Sciences of the University of Groningen an attempt was made to develop and implement new protocols in quality assurance to meet the regulations on the one hand and at the same time create conditions for further educational development. As an example, we describe a case in which all lecturers needed to fill in a form to explain the design of the course and justify the assessment methods. Strategies are presented in developing and implementing this form in such a way that it benefitted professional development of staff members and curriculum development in the study programme of chemistry.

Strategies

In this case two key strategies were used to develop and implement the protocols. First, using the introduction of the model of Constructive Alignment (Biggs, 1996) in the instructions for lecturers about how to follow the protocols and fill in forms, was expected to support them in rethinking the design of the course by formulating (new) learning objectives, improving the assessment quality and implementing innovative teaching methods. Second, implementing the protocols according to the model of Infrastructure, Authority and Consensus (IAC model, e.g. (Havelock & Huberman, 1978)) was expected to benefit the implementation of the protocols on a large scale in a short period of time. The Infrastructure of the developed protocols, the Authority of the accreditation committee, and the Consensus among the Faculty Board, directors, programme coordinators and lecturers about the implementation of the protocols resulted into a wide spread introduction of the concept of Constructive Alignment among lecturers.

Effects in educational development within the Faculty

It was found that by using the two models in implementing the protocols, staff members developed a better overview about the curriculum, were able to explain why problems occur in student learning and start initiatives to improve the programme. For example, curriculum committees were installed to develop learning progressions in academic skills, to develop a plan to implement learning communities and discuss with lecturers of other programmes to collaborate in developing courses. Besides by rethinking their course design and sharing their experiences, lecturers became motivated to develop and implement innovative teaching methods and improve classroom practices. For example, a group of lecturers collaborated with the student association in implementing the innovative educational models as 'Flip the Classroom' (Bishop & Verleger, 2013). During professional development activities within the Faculty, it was found that lecturers were more familiar with the basic concepts of course design. This provided opportunities to discuss about course design, teaching methods, pedagogical approaches on a more complex level. This will benefit future professional development of staff members and educational development within the Faculty.

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A Pedagogical Framework for Graduate Teaching Assistants to Promote Meaningful Learning in the General Chemistry Laboratory

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The Graduate Teaching Assistant (GTA) is deemed to be the most important person in the laboratory (Herrington & Nakhleh, 2003; Lazarowitz & Tamir, 1994; Pickering, 1988; Ryan, 2014). GTAs are close to undergraduate students (UGs) in terms of age and student status (Golish, 1999; Muzaka, 2009) and they are often present in the laboratory in greater numbers than the single module leader. As a result, GTAs are believed to have a profound influence on UGs' learning experiences in the chemistry laboratory (Bond-Robinson & Rodriques, 2006; Herrington & Nakhleh, 2003).

This research set out to develop, implement and evaluate a pedagogical framework for GTAs that would seek to promote meaningful learning experiences for UGs during first year, General Chemistry laboratory sessions. The pedagogical framework is theoretically underpinned by Ausubel and Novak's construct of meaningful learning (Novak 2010, Ausubel 1963, Brandriet et al. 2013). This theory of education postulates that meaningful learning is derived from the construction of new information from prior knowledge through the integration of the affective, cognitive and psychomotor domains of learning.

This framework was implemented throughout a series of workshops with seven GTAs who assisted in the delivery of first year, undergraduate General Chemistry laboratory sessions. Evaluating the implementation of this framework involved the collection and analysis of the following forms of data:

- Audio recordings of the verbal interactions between participating GTAs and UGs before and after the workshops. These recordings were analysed in respect to how GTAs addressed the development of UGs' cognitive, affective and psychomotor domains.
- Documentation of the workshop proceedings.
- Field notes based on observations of the GTAs in the laboratory before and after the workshops.
- Early interpretations of the findings reveal a shift in the nature of the verbal interactions between GTAs and UGs in the General Chemistry laboratory as a result of participation in the workshops. From the workshop documentation, insights were also gained into how the GTAs applied the framework to the content associated with specific General Chemistry laboratory sessions.

This presentation will provide insight into the features of the chemistry laboratory GTA framework as well as insights into its effect on the nature of the verbal interactions between GTAs and UGs in the laboratory.

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Real-time experiments to enhance Chemistry Competencies in Secondary. What does it make the difference?

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In this communication, students' performances in the activities of a project, that has the aims of enhancing the acquisition of science competencies in secondary school students using real-time experiments, are analyzed. Researchers on Science Education from six Universities belonging to five EU countries designed the activities.

A new research-based framework for teaching activities that use real-time experiments was created and new activities of Chemistry, Physics and Biology were designed. The activities are inquiry-guided, context-based and student-centered. They aim to enhance in learners the design of experiments and the analysis and communication of results. The designed activities have been implemented with secondary students in five countries. Data on motivation was taken using pre-post questionnaires. Data on understanding of the activities has been obtained using a post questionnaire. This work aims to answer the following research questions: (1) Are there differences between activities in relation to students' performances?; and (2) What are the key aspects of the activities in which students perform better?

21 of the designed activities (including 5 activities for Physics, 12 for Chemistry and 4 for Biology) were selected for implementation and the research data of 1354 cases was collected for Physics ($N = 184$), Chemistry ($N = 828$) and Biology ($N = 342$). Several statistical methods where used to process the data including descriptive statistics, frequency analysis, cluster analysis and non-parametrical statistical methods (Mann-Whitney U Test and Kruskal-Wallis H Test) to compare the relevant groups in order to answer the above-mentioned questions.

The findings show that the activity itself is probably the most important factor generating statistically significant differences in all inspected aspects. We also found that activities for different subjects were perceived differently by the students and the activities for Biology seem to be comprehended better and perceived more positively then activities for Chemistry and Physics. An interesting fact is that the activities performed at schools were perceived differently when performed in universities. The results also intimate that in the most aspects there is no significant difference between male and female students in how they understand and apprehend the activities. Furthermore, in the communication we try to identify the fundamental aspects of the activities in which students perform more successful.

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MBL inquiry experiments to enhance science skills and chemistry competencies at secondary school: Practice and research results

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Abstract

This communication provides preliminary findings of how research-based MBL activities, some created in COMBLAB project and refined after implementation, can help students to develop inquiry skills, such as the design of experiments, collection, analysis and data processing to answer an investigable question arising from a context situation.

The activities and research results of the COMBLAB project (The acquisition of science competencies through ICT real time experiments. Project number: 517587-LLP-1-2011-1-ES-COMENIUS-CMP) provide framework and background of this work group aimed at developing and analyzing implementation results of activities to enhance scientific skills.

An innovative work team of CESIRE in Catalonia has continued beyond the European project with the aim of deepening aspects related to improving scientific skills such as the design of experiments, the interpretation of results and their communication. The interest in focusing on the improvement of this specific element or dimension of scientific competence is to create and implement available activities and tested teaching materials to develop and evaluate the competence "Identify and solve scientific problems that could be investigated in schools, including design, implementation and communication of experimental investigations", included in the curricular document "Scientific-technological Core Competencies" (Departament d'Ensenyament).

This communication presents results to answer research questions such as: Does real-time MBL experiments help students design, process and interpret the results of students' experimental research? Most of students ***strongly agreed*** or ***agreed*** with the questionnaire item "using MBL equipment helped me to interpret the results", although most of them, especially among Catalan students, had never used this equipment, or less than once or twice. Most students agreed that it was easy to obtain data from experiments designed with MBL tools. Some questions to test the progress of students in such specific science skills and competences further were designed and the results analyzed.

The analysis of other items of the COMBLAB project questionnaire led to comparing students' answers among the European countries engaged in the COMBLAB project and the post-project implementation in Catalonia. Students also consider that activities proposals are understandable so they can perform group working, and that they also need a teacher as guide. The most important difficulties detected by students have also been analyzed.

Results are obtained from a sample of more than 1000 students that have performed Chemistry activities created during the COMBLAB project and refined after implementation by the Catalan team members. The results obtained by students at school labs, and empirical data on student's perceptions have been analyzed.

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Professionalization of future chemistry teachers for teaching in inclusive classes

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By the ratification of the UN Convention on the Rights of Persons with Disabilities in 2009, Germany has agreed to shift to an inclusive school system, where students with and without disabilities are taught together (United Nations, 2006). The development of a teaching practice, which supports every student in accordance with its individual skills and the resulting (special) education needs in general education schools, means a new requirement for the teachers. Thus, the teacher training must build the basis for implementing the inclusive education at schools in Germany (Amrhein & Dziak-Mahler, 2014).

This project aims to develop and to evaluate a seminar, which shall prepare future chemistry teachers for teaching chemistry in inclusive classes. The seminar is based on the principles of the ***Universal Design for Learning*** (UDL), an accepted framework for guiding educational practice that reduces barriers and provides flexibility in instruction, teaching methods and materials and classroom activities (HEOA, Public Law 110-315, August 14, 2008, S. 3088). It constitutes a concept for designing teaching in inclusive classes (Rose & Meyer, 2002). The seminar focusses on both, the special education aspects of teaching and learning, and the methods and means for an inclusive teaching creation. After the seminar, the future teachers have the opportunity to implement what they have learned in the subsequent internship semester in school practice.

By using different testing tools, the levels: 'attractiveness', 'cognitive changes', and 'teaching acting' and 'effect on the learners' shall prove the success of the seminar (c.f. Kirkpatrick & Kirkpatrick, 2006; Schmitt, 2015). The 'attractiveness' of the seminar and the students' 'cognitive changes' due to the participation are determined during the seminar. 'Teaching acting' and 'effect on the learners' are evaluated during the subsequent internship semester. Thus, the overall duration of the investigation extends over two semesters.

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Inclusion in Chemistry Education in Secondary School

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The amendment of the ninth school law act of North Rhine-Westphalia in 2013 (NRW, 2013) is in accordance with the UN-Convention on the Rights of Persons with Disabilities (UN-CRPD) from 2009, which requires the right of equal participation for students with and without special educational needs (Deutsches Institut für Menschenrechte, 2009). The demand for inclusion does not mean that the curriculum is designed entirely uniquely, but rather that the students work on the same content individually (Kullmann, Lütje-Klose & Textor, 2014). Therefore, teaching an inclusive learning group aims at improving the proficiency level of each learner as well as working on a joint learning content for the whole class. The implementation of inclusive teaching is problematic as there are only few and insufficient learning resources, especially in the field of science education. In order to find a more efficient method of implementing inclusive teaching, a concept was developed that combines instructive elements, constructive phases and the Universal Design for Learning (UDL, Center of Applied Special Technology, 2011). The UDL focuses on inclusive learning groups and is a framework for designing inclusive learning environments. Its intention is to create working space for all kind of students. The main idea is to involve all students in the learning process by offering varied ways to access a certain content. Three principles are essential for the UDL: the questions of what to learn, why to learn and how to teach. They cover the dynamic process of teaching and learning.

The aim of this study is to develop and evaluate an inclusive teaching unit in chemistry education. On the one hand, it contains a lecture, given by the teacher; on the other hand, the learners use a self-evaluation sheet in order to identify their own learning capabilities and proficiency levels. After that, they work with material that is based on the UDL. The study is carried out with two groups of secondary education students (Grade 8, N ~ 220). Both groups deal with the same material in a 225-minute inclusive teaching unit. The difference between the groups is their composition: The intervention group is an inclusive learning group, while there are no students with disabilities in the control group.

The talk will present the design and first results of the study.

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A trail over conceptual stepping stones: ancient technologies and models in introductory chemistry course for 6-7 grades

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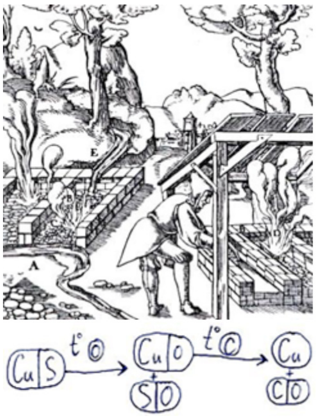
In order to develop a solid understanding of and master the core chemistry concepts, novices should make several big advances in the way they think about materials around them (e.g. Johnson, Tymms, 2011; Tsaparlis, Sevian 2013). Our innovative introductory course for 6-7 grades (Vysotskaya, Khrebtova & Rekhtman, 2015) strives to scaffold and support students' progress from a naïve point of view of materials as objects towards a more sophisticated view based on the elemental composition of materials (Ngai, Sevian & Talanquer, 2014). Students start by exploring unlabeled substances and their transformations to make them at least more predictable. This way, students' activities revolve around the task of preparation of a certain substance from available reagents and verifying the result. Planning the experiments, comparing the results, modelling the transformations and, later, the composition of involved substances, etc. – all such activities require an external source of information to query. We assume the latter to be a short text having (1) a description of a process or substance of interest and related ones with their easily recognizable properties; (2) a comment on significance of the processes or substances to people in the past; (3) hints on application of simple models previously built by students; (4) neither chemical names nor formulas. The process description needs to be as simple as possible to be at least partially testable by students on the lab table. Descriptions of ancient techniques such as salt processing, dyes preparation and dyeing, metal smelting, etc. can be helpful for the purpose (Scheffel, Brockmeier & Parchmann, 2009; Matthews, 2014; Niaz, 2016). A set of such essays has been compiled, tested, and revised during the fourth long-term macro-cycle of our design research experiment in 6-7 grades. Students' outcomes show that the most efficient is the approach in which students, at first, interpret a given text through their available models previously built in the classroom, and after that plan a new set of experiments to verify their understanding of the process of interest. Along this way, students learn how to read and comprehend 'chemical' texts, what stands behind chemical symbols and terms, why they are useful, and, on top of that, realize the significance of chemistry for people's life in the past and present. We believe that students' perception of chemistry as an important, interesting, and understandable part of human culture is worth an effort.



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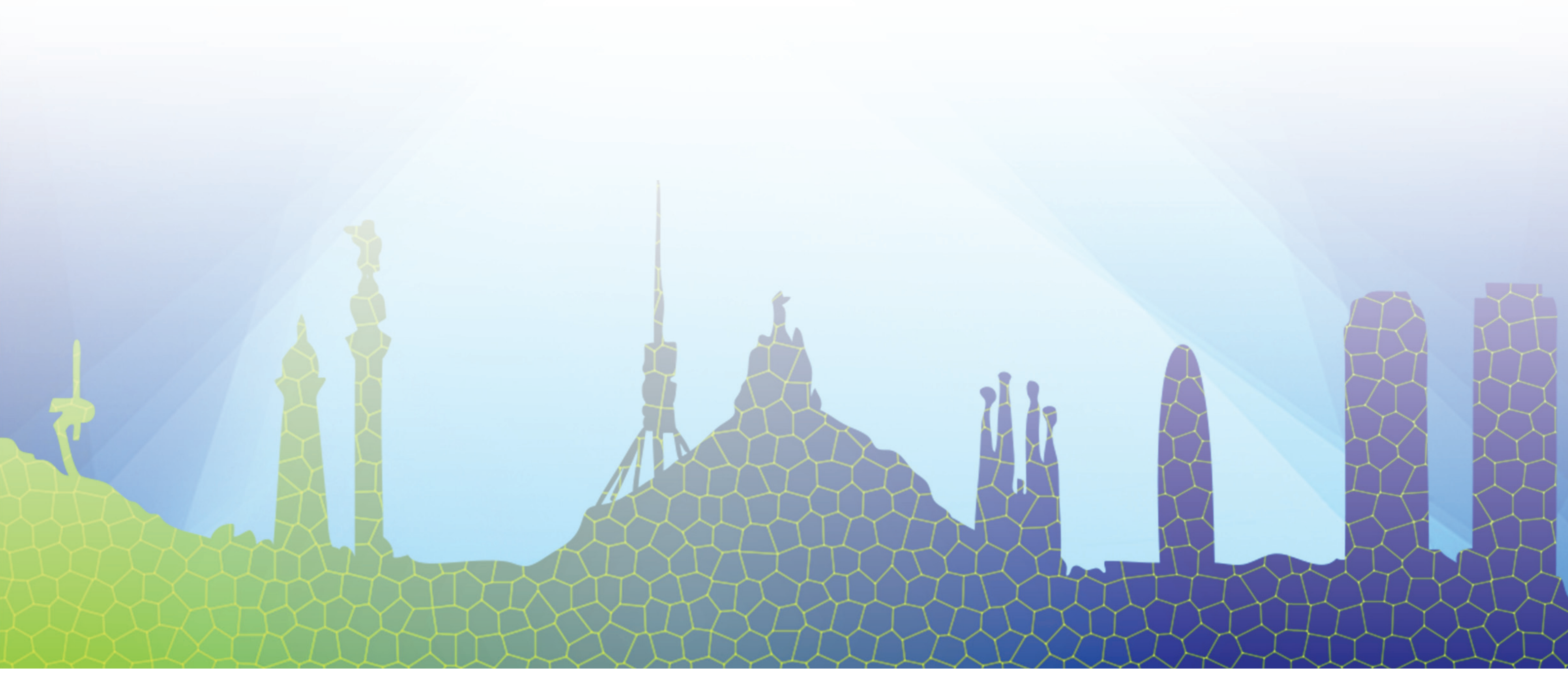

Posters

POSTER COMMUNICATIONS PC1 (CLOISTER – 1ST FLOOR) WEDNESDAY 7TH SEPTEMBER (HUNG ALL DAY) (P1-P30)			
11:25 h -12:10 h (PRESENTATIONS OF PC1.1 (P1-P15) AND 15:50 H – 16:35 H (PRESENTATIONS OF PC1.2 P16-P30)			
	POSTER COMMUNICATIONS PC1	**LIST OF PC1.1: PRESENTATION BY THE AUTHORS (11:25 h -12:10 h)** **Chair:** Consol Blanch, *University of Vic*, Spain	
P1	Group Exam As A Form Of Assessment	Koliseva, Anniina; Matilainen, Rose *University of Jyväskylä*	Finland
P2	H. E. Armstrong (1848-1937): the forgotten pioneer of IBSE	Peter E. Childs *University of Limerick, Ireland*	Ireland
P3	Investigating Motivation To Learn Chemistry And Physics Among Students Of Tertiary Education	Salta, Katerina; Koulougliotis, Dionysios *University of Crete*	Greece
P4	Learning Strategies Of Students In Relation To Learning Chemistry	Kmetova, Jarmila; Skorsepa, Marek *Matej Bel University*	Slovakia
P5	Meaningful First Year Experience Prevents Dropouts In Chemistry	Valto, Piia , Kiviniemi, Tiina , Lundell, Jan *University of Jyväskylä*	Finland
P6	Reconstruction Of University Level Analytical Chemistry Laboratory Course	Välisaari, Jouni , Koliseva, Anniina , Valto, Piia , Matilainen, Rose *University of Jyväskylä*	Finland
P7	Students As Participants In Curriculum Redesign: Development Of A Project Based Introductory Chemistry Laboratory Curriculum	Lykourinou, Vaso; Lee-Parsons, Carolyn; de la Parra, John; Rovira, Alejandro *Northeastern University*	USA
P8	Learning From Errors: New Strategies To Improve The Evaluation Of Equilibrium Constants	Clotet Romeu, Anna; Mas, Elisenda; Reguero, Mar; Campanera, Josep M.; Carles Bo *Universitat Rovira i Virgili*	Spain
P9	Developing And Implementing An Innovative Digital Template For Research And Design Projects In Academic Science Education	Wolfs, Peter; Dolfing, Ria *University of Groningen*	The Netherlands
P10	The Change Of Functionality–The Development Of Chemical Synthesis Since The Days Of Alchemy	Frevert, Mareike *University of Kassel*	Germany
P11	Turning Your Spreadsheet Into An Always Updated Chemistry Handbook	Cuadros, Jordi *IQS Univ. Ramon Llull*	Spain
P12	The Impact Of School Field Trip On Students¿ Environmental Awareness Towards Plastic Pollution	Tağmay Yılmaz(1); Sevil Akaygun *Adapazarı ENKA High School*	Turkey
P13	Personal Construct Psychology (PCP) As A Theory To Inform A Proposed Model Of Learning	Odilla E. Finlayson; Enda P. Carr; Eilish McLoughlin *School of Chemistry, Dublin City University*	Ireland
P14	Teaching Chemists Crystallography–Modern Or Obsolete?	Lipkowski, Janusz *Cardinal Stefan Wyszynski University in Warsaw*	Poland
P15	Exploring General Chemistry Students' Cognitive Abilities And Domain-Specific Skills In The Context Of Stoichiometry	Gulacar, Ozcan;, Eilks, Ingo; Bowman, Charles; Milkey, Alexandra *University of California-Davis*	USA
	POSTER COMMUNICATIONS PC1	**LIST OF PC1.2: PRESENTATION BY THE AUTHORS 15:50 h – 16:35 h** **Chair:** Àngel Messeguer, IQAC *Institut Química Avançada de Catalunya*, CSIC, Spain	
P16	Monitoring Authentic Chemistry Problem Solving With The Eye-Tracking Method	Devetak, Iztok; Slapnicar, Miha; Glažar, Saša Aleksij *University of Ljubljana*	Slovenia

P17	Students' Focus On 2d And 3d Images Of Molecule Models When Solving Simple Chemical Task	Devetak, Iztok; Svetičič, Špela; Torkar, Gregor *University of Ljubljana*	Slovenia
P18	Contemporary Science In Chemistry Teacher Education ¿ An Empirical Study	Frevert, Mareike , Di Fuccia, David-Samuel *University of Kassel*	Germany
P19	Primary School Teachers¿ Beliefs About Learning In Science And Their According Action In The Classroom	Dunker, Nina Kim *University of Bielefeld*	Germany
P20	School-University Partnership: A Potentiating Tool To Reflect On The Teaching Practice	Mendes da Silva, Joaquim Fernando; Pinho, Gabriela; Lima, Maria Celiana; França, Mauro; Araújo, Sheila; Heidelmann, Stephany *Federal University of Rio de Janeiro*	Brasil
P21	Professional Teaching Competencies And Didactical Models Of Beginning Teachers In Sciences.	Jara Campos, Roxana; Morales Cisternas, Cecilia; Quiñones Herrera, Paola; Satlov *Vega, Miriam* *Pontificia Universidad Católica de Valparaíso*	Chile
P22	Comparison Of Two Digestion Methods For The Analysis Of Metals In Different Sample Matrices By Chemistry Undergraduate Students.	Oliva, Bessie; Véliz, Ricardo; Archila, Ilse; Marchorro, Iris *University of San Carlos of Guatemala*	Guatemala
P23	Implementation Of An Experimental Procedure For The Extraction And Analysis Of Volatiles From A Guatemalan Aromatic Plant By Spme.	Perez-Sabino, Francisco; Taracena, Edwin; Mérida-Reyes, Max; Hernández-Hernández, Elisandra *University of San Carlos of Guatemala*	Guatemala
P24	"Locus: A Real Adventure": An Rpg (Role-Playing Game) As An Alternative Instrument To Promote Citizenship And Environmental Education	Mendes da Silva, Joaquim Fernando; Vianna Francisco, Tatiana *Federal University of Rio de Janeiro*	Brasil
P25	Synthesis Of Novel 2-Heterostyrylbenzimidazoles As Potential Anti-Tuberculosis Agents: A Scientific Approach	Taduri, Ashok Kumar; Bhoomireddy, Rama Devi *Jawaharlal Nehru Technological University Hyderabad*	India
P26	A Didactic Sequence To Explore Socioeconomic Issues Of Modern Africa In Chemistry Education	Mendes da Silva Joaquim Fernando; Heidelmann, Stephany; Pinho, Gabriela *Federal University of Rio de Janeiro*	Brasil
P27	Integrating The Essential Nanoscale Science And Technology (Nst) Concepts In High School Chemistry Curricula In Israel	Blonder, Ron; Sakhnini , Sohair *Weizmann Institute of Science*	Israel
P28	Exploiting The Responsible Research And Innovation Dimensions In Science Education–Results Of The Engage Project	Gorghiu, Laura Monica; Gabriel Gorghiu,; Mihai Bîzoi, *Valahia University Targoviste*	Romania
P29	Cheminformatics Olcc: Teaching A Class On Cutting-Edge Digital Technologies Across Multiple Campuses	Cuadros, Jordi *IQS Univ. Ramon Llull*	Spain
P30	Discovering the liquid gold of the Mediterranean: A Chemometrical Approach to the study of olive oil	Iris Carretero; Montserrat Mialet *Col·legi Escorial. Vic*	Spain
POSTER COMMUNICATIONS PC2 (CLOISTER – 1ST FLOOR) FRIDAY 9TH SEPTEMBER (HUNG ALL DAY) (P31-P58)			
10:50 h – 11:35 h (PRESENTATIONS OF PC2.1 (P31-P43) AND 15:50 H – 16:35 H (PRESENTATIONS OF PC2.2 (P44-P58)			
	POSTER COMMUNICATIONS PC 2	**LIST OF PC2.1. PRESENTATION BY THE AUTHORS 10:50 h – 11:35 h** **Chair:** Aureli Caamaño, *Societat Catalana de Química, IEC*, Spain	
P31	Introducing Inorganic Ions Qualitative Determination Tests In Lower-Secondary School Elective Course Experiments In Chemistry	Devetak, Iztok; Založnik, Urša *University of Ljubljana*	Slovenia
P32	The Atomic Force Microscope AFMone® As Clearly Arranged Self-activity Access To Nanomaterials In Teacher Education	Goldhausen, Ines; Bode, Janina; Di Fuccia, David-S *University of Kassel*	Germany

P33	Analysis And Reflection Of Different Learning Paths Towards Electro Chemistry	Katharina Groß *University of Cologne*	Germany
P34	Development and Validation of a Basic Chemistry Concept Inventory Assessing Secondary School Students	Salta, Katerina; Antonoglou, Lemonia; Vlacholia, Maria; Rousss, Petros; Kazi, Smaragda; Vosniadou, Stella; Sigalas, Michael; Zougraki, Thryssa *National and Kapodistrian University of Athens*	Greece
P35	Chemie Im Kontext In Spain: The Adaptation Of A Context Bases Methodology For Chemistry Teaching	Sanchez-Diaz, Ignacio; Di Fuccia, David-S. *University of Kassel*	Germany
P36	The greenhouse effect through experimentation activities to develop the argumentation capacity	Guerra , Antonio; Almeida, Caroline; Silva, Joaquim *Federal University of Rio de Janeiro*	Brasil
P37	Using Different Teaching Aids To Enhance Conceptual Development Of Students In A Chemistry Classroom	Uamusse, Amália; Kuleshov, Tatiana *Eduardo Mondlane University*	Mozambique
P38	Coal Power and acid rain: A COMBLAB activity to enhance chemistry competencies at secondary school	Guitart Mas, Fina; Aguilera Juan, Tomás Luís; Franch Ventura, Pere; Mas Llorens, Montserrat; Rios Flor, Consuelo; Tortosa Moreno, Montserrat *CESIRE Departament d'Ensenyament and University of Barcelona*	Spain
P39	Real-time experiments to enhance Chemistry Competencies in Secondary: The most efficient home-made fire extinguisher	Tortosa, Montserrat; Guitart, Fina; Artigas, Carme; Bofill, Sonia; Mas, Montserrat; Ramírez, Joan *INS Sabadell*	Spain
P40	Butterfly effect in a chemical oscillator	Pilosu, Vittorio; Budroni, Marcello A.; Wodlei, Florian and Rustici, Mauro *University of Sassari*	Italy
P41	Design teaching sequences with augmented reality to promote visualization in chemistry.	Merino; Cristian; Arellano, Marcela; Quiroz, Waldo , Nilo, Nicole , Olivares, Carla , Vargas, Jonathan , Berna, Sergio; Paipa, Carolina; Miriam Struchiner *Pontificia Universidad Católica de Valparaíso*	Chile
P42	Supporting In-Service Chemistry Teachers to Pedagogical Effectively Integrate Virtual Laboratory in their Teaching through a Blended Professional Development Program in Greece	Antonoglou, Lemonia; Psillos, Dimitrios; Athanasios Taramopoulos *Aristotle University of Thessaloniki*	Greece
P43	An Activity for Teaching Heat Concept to Visually Impaired Students	Sozbilir, Mustafa; Kizilaslan, Aydin; Zorluoglu, Levent *Ataturk University*	Turkey
	POSTER COMMUNICATIONS PC 2	**LIST OF PC2.2. PRESENTATION BY THE AUTHORS 15:50 h – 16:35 h** **Chair:** Gabriel Pinto, *Universidad Politècnica de Madrid*, Sapin	
P44	Mathematical Modelling In Chemistry Lessons–Theory And Reality	Goldhausen, Ines *University of Kassel*	Alemania
P45	Designing A Curriculum That Gives Students A Relevant, Meaningful, Interesting And Worthwhile Experience Of Chemistry	Farrugia, Josette; Mizzi, Doreen; Zahra, Richard; Zarb, Dennis *University of Malta*	Malta
P46	What Happens With Students At Gymnasium Level ¿ Is There Any Change Of The Levels Of Scientific Literacy?	Rannikmäe, Miia; Soobard, Regina; Reiska, Priit *University of Tartu*	Estonia
P47	Particles: What Are They? A Proposal On A Learning Progression About The Particle Model Of Matter For Upper Secondary School	Moltó, María Ángeles; Hernández, María Isabel; Pintó, Roser *Universitat Autònoma de Barcelona*	Spain
P48	Students' Self-Perceptions About Big Ideas In Science Education	Rannikmäe, Miia; Ait, Kerti; Holbrook, Jack *Tartu University*	Estonia

P49	Visualisation Of Hydrogen Bond In Water Dimer: Representations By Finnish Teacher Students And In-Field Teachers	Pyykkö, Lassi; Rajamäki, Nea; Lundell, Jan *University of Jyvaskyla*	Finland
P50	Phenomenological Primitives (P-Prims) In Chemistry	Zoltán, Tóth; Zsolt, Bárány *University of Debrecen*	Hungary
P51	Results Of The Project "Yum Yum… Good This Science!" How To Deal With Food Chemistry And Education At The Primary School	Domenici, Valentina; Gerardi, Chiara *Università di Pisa*	Italy
P52	Inspiring Early Elementary School Students (Grade 1, 2 And 3) With Chemistry. Stem Program At Anatolia College In Greece	Antonoglou, Lemonia; Kalampokis, Ilias; Hatziantoniou Maroulis, Constantina *Aristotle University of Thessaloniki and Anatolia Elementary School*	Greece
P53	Science Education In Out-Of-School Contexts' Comparison Of Users' And Providers' Ambitions And Perceptions	Goldhausen, Ines; Di Fuccia, David-Samuel; Ralle, Bernd *University of Kassel*	Germany
P54	Engaging Future Teachers To Promote Rri: Implementing Engage Project Digital Materials Related To Chemistry Big Ideas	Guitart Mas, Fina; Alcaraz-Dominguez, Silvia; Barajas, Mario *University of Barcelona*	Spain
P55	Playing With The Sense of Smell. A Workshop To Improve Organic Chemistry And Food Science Education	Blanch, Consol; Simon, Montse *University of Vic-UCC*	Spain
P56	Authentic/Alternative Assessment, V: Classification of Organic Compounds, Reactions/Mechanisms by Science Majors	Moisés Camacho *University of Puerto Rico at Mayagüez*	Puerto Rico
P57	Authentic/Alternative Assessment, V: Performance of Science Majors/Non-Majors on the Categorizing Grid	Moisés Camacho *University of Puerto Rico at Mayagüez*	Puerto Rico
P58	Authentic/ Alternative Assessment in Chemistry/Science Education V: The Effect of the Auto Quiz on the Achievement of Science College Students	Moisés Camacho *University of Puerto Rico at Mayagüez*	Puerto Rico

Group exam as a form of assessment

Anniina Koliseva and Rose Matilainen

Department of Chemistry, University of Jyväskylä, Finland Since autumn 2012, students at the department of Chemistry at the University of Jyväskylä have had the opportunity to participate in a group exam besides the traditional, individual exam, as a way of completing analytical chemistry courses. Students take the exam in groups of 2-3 students. Questions are similar in both group and individual exam.

Feedback about the group exam was collected through an online questionnaire from the students of three courses during the years 2012-2013. From the feedback we wanted to clarify the group exam's functionality and its effect on the grades, and also to discover students' overall experiences. 59 students filled in the questionnaire.

Overall the group exam was a positive and pleasant experience for students. 78% of the respondents found that the group exam was also a learning experience, and 98% of them would participate in a group exam again. Students expressed that a group exam was less stressful than a traditional individual exam. The support of the other group members helped to ease feelings of anxiety during the exam. Working in a group required the students to express and validate their opinions and thoughts as they had to consider the questions more profoundly. Students knew how to utilize one another's strengths while completing the tasks, learning more at same time themselves.

No direct link was found between the group exam's effectiveness on grades. However, students who participated in the traditional exam failed more often. Nevertheless, based on earlier studies, group work and cooperative learning have a positive effect on learning result. [1,2]

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H. E. Armstrong (1848-1937): the forgotten pioneer of IBSE

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Most books and articles discussing the origin of inquiry-based learning identify the Americans John Dewey (early 1900s) and Jerome Bruner (1960s) as the originators. However, the idea of heuristic, or discovery, science teaching in secondary schools, was first suggested and promoted by an English professor of Chemistry, H.E. Armstrong from the 1880s onwards. His ideas and influence in the U.K. in the early 20th century, at a time when science teaching was just beginning to be recognised as a core subject in schools, has been overlooked in the history of inquiry-based science education (IBSE). Armstrong promoted his idea that learning science should be by doing not just by listening from around 1884, in a series of lectures and articles (Armstrong, 1902; Brock, 1973) until his death in 1937. Armstrong had been influenced by the German school of research-based teaching, first pioneered by Justus von Liebig, and his own experiences of teaching chemistry at post-secondary level made him realise the deficiencies of contemporary school science education. He changed the way he himself taught and started to promote his ideas to scientists, the public and to teachers. Armstrong's new way of teaching science he termed heurism, after the Greek for 'I discover', and it focused on student inquiry and hands-on learning. He defined heuristic methods thus:

"Heuristic methods of teaching are methods which involve placing students as far as possible in the position of discoverers,—methods which involve their finding out instead of being merely told about things."

He was able to get his ideas accepted in Christ's Hospital, an influential public (private) school, and the school and its succession of great science teachers, provided a test-bed for his ideas. Armstrong had a major influence on the way science was taught in the U.K. in the early part of the 20th century, but the pressure of the examination system and the lack of experienced teachers led to heuristic teaching falling out of use. However, Armstrong was the source of a stream of science pedagogy based on inquiry which eventually grew to full flow in the Nuffield science teaching projects of the 1960s. Gordon van Praagh (1909-2003) was a key contributor to the Nuffield schemes and he had taught at Christ's Hospital and had been infected by what has been termed the ***virus heuristicum Armstrongii.*** The Nuffield projects were based on discovery learning and this in turn affected the science teaching in many countries in the 1970s and 80s, leading to today's emphasis on IBSE.

In this talk I will revive the memory and legacy of H.E. Armstrong and his contribution in the early 20th century to what was then a new science pedagogy. This 'new pedagogy' of IBSE was rediscovered by the Rocard Report (Rocard, 2007).Armstrong's ideas and his experience of trying to establish inquiry-based learning in schools offers important lessons for today. If we do not learn from the past we are doomed to repeat it.

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Investigating motivation to learn chemistry and physics among students of tertiary education

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The growing relevance of science in daily life and its influence on many everyday situations have never been so pronounced. Therefore, there is a need for science literate citizens who are able to make informed decisions about science-related issues. Current research suggests that motivational enhancement would have to accompany conceptual change to promote public understanding of science.[1] Furthermore, it has been shown that the interaction between student motivation and the content of specific academic disciplines is an important determinant of student achievement.[2] Recent research indicates that even in pre-primary school, children express some differences in their motivation toward different science disciplines.[3] Therefore, it is both interesting and necessary to separately investigate the motivation to learn chemistry and physics among students in secondary and tertiary education.

This paper describes the results of a study about Greek tertiary students' motivation to learn chemistry and physics using the Greek version of discipline-specific Science Motivation Questionnaire II (SMQ II[4,5]. The study was conducted in 3 academic departments of the Technological Educational Institute (T.E.I.) of Ionian Islands. The participants were 281 students, 105 males and 176 females. Most students in the sample were of middle socioeconomic status. The students participated voluntarily without extra credit or compensation for their participation.

The current study provides strong evidence for the validity and reliability of the recently adapted chemistry-specific Greek version of SMQ II[5] in measuring motivation in the physics discipline as well as among students in tertiary education. Discipline-based comparisons showed that students had higher motivation to learn chemistry relative to physics. The differences are statistically significant between all means of the five motivation scales. In addition, students reported more positive experience from the attendance of chemistry relative to the physics courses both in high school and university. More detailed comparisons related with gender and the specific academic department were conducted and provide insights as well as stimulus for further research.

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Learning Strategies of students in relation to learning Chemistry

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In the communication the preliminary findings of a research inspecting learning strategies of secondary school students within the education of Chemistry are provided. The still-running research has been including more than 2 000 respondents who administered the renowned Motivated Strategies for Learning Questionnaire (MSLQ) created by Pintrich et al. (1991, 1993) for assessing students' motivational orientations and their use of different learning strategies for college courses. In compliance with this study aim we used only the second section (learning strategies) of the original tool to target Slovak students' use of different cognitive and metacognitive strategies (31 items divided into 5 subscales) related to learning Chemistry. In addition, the learning strategies section includes 19 item (4 subscales) concerning students' management of different resources. All considered subscales are following: (i) ***Rehearsal***, (ii) ***Elaboration***, (iii) ***Organization***, (iv) ***Critical Thinking***, (v) ***Metacognitive Self-Regulation,*** (vi) ***Time and Study Environment***, (vii) ***Effort Regulation***, (viii) ***Peer Learning*** and (ix) ***Help Seeking***.

The study has an ambition to answer several research questions, such as: (1) What is the preferred combination of students' learning strategies in relation to learning Chemistry? (2) Does gender, specific school and age of the student influence his/her learning strategies? (3) Can students be layered (classified) according to their preferred learning strategies? (4) Is there a relation between student's self-perceived learning strategies and the final grades they achieve in Chemistry?

As the research is still running, this communication considers the preliminary findings resulting from the first 754 administrations only. Several statistical methods including descriptive statistics, frequency analysis, analyses of variance, a cluster analysis and correlation analysis were used to process the data. The satisfactory reliability level of the data was confirmed by estimation of internal consistency within the subscales expressed by the Cronbach's alpha coefficient. Confirmatory factor analysis (CFA) was performed with the data considering several potential structure models of the dimensions measured and the suitable level of construct validity was confirmed.

The preliminary results indicate only minor differences in self-perceived learning strategies dimensions generated by gender and a specific school attended by a student. On the other hand, the students of different class (year of study) differ significantly mainly in ***Elaboration***, ***Critical Thinking*** and ***Metacognitive Self-Regulation***. The hierarchical cluster analysis (using Ward's method of agglomerative clustering) suggests that students can be layered into 3 or 4 reasonable clusters according to the similarities in their perceived learning strategies. Based on the correlation analysis our outcomes also intimate that in some cases the final grade achieved by a student in Chemistry can be used as a predictor of the complex of learning strategies dimensions.

Having some empirical evidence about the specifics of students' learning strategies we have to conclude that farther research and more data is needed to comprehend deeper relations necessary to uncover the whole package of aspects related to learning strategies that students prefer in learning Chemistry.

Support from the national project KEGA 029UMB-4/2014 is gratefully acknowledged.

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Meaningful first year experience prevents dropouts in chemistry

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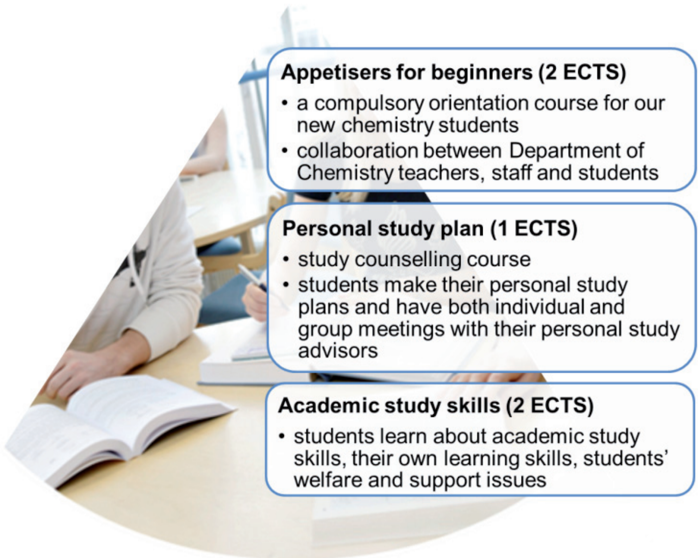
The first year of university studies in chemistry is challenging for many students and has a strong impact on their subsequent studies. The interaction between students, the Department activities, teaching personnel and University life is important. At Department of Chemistry, the students' engagement and study motivation are increased by enhanced study counselling, collaborative interaction between students and personnel, integrated study programs and intensive welcoming course for the new chemistry students. An enhanced study and counselling model for first year students includes for example introductory course for chemistry studies, study counselling course and academic study skills course.



The preliminary assessment of the model has been made by evaluating students' dropout rate and studying success by measuring their overall ECTS credits during first study year. The number of students performing 55 ECTS credits during first study year has been increased from 21 % to 68 % between years 2009 and 2013 (Valto, 2015; Valto & Lundell, 2015). In addition, we have also evaluated how first year study experience affects students' willingness to continue their studies among our chemistry program. It seems, that over 50 % of the students whose chemistry studies were a secondary choice, still continued their studies in our Department. Consequently, it is evident that our first year model increases the number of students continuing their studies and also improves their study success.

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Reconstruction of university level analytical chemistry laboratory course

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The analytical chemistry laboratory course in our department was reconstructed due to problems in the traditional arrangement, structure and contents of the course. The main purpose of the reform was to increase student-centered activity, co-operation and inquiry-based learning. We also wanted to strengthen the connections to everyday life, to develop students' critical-thinking skills, and to decrease the number of drop-outs during the course. The reconstruction of the course was based on students' feedback and ideas reported in literature [1-3].

The course is a part of subject studies in chemistry at Bachelor's level, and is equivalent to 4 ECTS credits. About 75% of students are chemistry majors. The reform was carried out during the autumn term 2014.

In the reconstructed course students worked in groups of 8–10 students. The course included independent laboratory working tasks, preliminary assignments and discussion on the results. The course also included a co-operational research project which was conducted in tutorial groups. The students' projects were presented in a course seminar.

In our study the opinions of 45 students and 6 teaching assistants were discovered through survey and interview study, respectively. Based on the survey, 96% of the students assessed the overall experience of the course good or excellent. 76% evaluated that their interest in the subject increased during the laboratory course, and 60% found analyzing their own samples meaningful. When the students were asked to describe their experience of the research project, 82% of their comments were classified positive and 18% negative. The students cited research projects motivating (31/45), educational (24/45), and they enjoyed team work (19/45). Negative comments covered mostly the practical implementation of the course.

The opinions of the teaching assistants were more hesitant. Some of the TA's enjoyed the new implementation of the course, but some of them preferred the traditional way of teaching.

The amount of drop-outs during the course decreased from 46 % to 11 %. Based on a preliminary assessment of the course, the new model increases students' interest in the subject, study motivation and the number of students completing the course.

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Students as participants in curriculum redesign: development of a project based introductory chemistry laboratory curriculum

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Abstract

In this curriculum reform we are seeking to improve learning outcomes in the general chemistry laboratory by making use of the unique attributes of this environment to introduce students to research approaches in chemistry by focusing on project based learning grounded in sustainability while making connections to departmental research. The goal is to successfully engage students in cooperative learning and help them develop experimental design skills while engaging in authentic research experiences designed to make them aware of green chemistry and sustainability practices in the chemistry laboratory.

The development team incorporates young undergraduate students who completed the pilot lab sessions and serve as peers to support teaching assistants in facilitation of lab courses and as co-developers of the curriculum. The team of faculty, graduate teaching assistants and students involved in this effort is currently working to refine experimental parameters for lab project guidelines, minimization of waste, development of online modules and media to best support instrumentation and technique competency and provide support in assessing learning outcomes. Details of laboratory projects currently developed where students work in optimizing extraction and identification of pharmaceutical intermediates from plants using greener solvents and supercritical fluid liquid chromatography in parallel with TLC will be discussed.

Learning from errors: New strategies to improve the evaluation of equilibrium constants

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The classical experiment of the iron(III)–thiocyanate complex formation is used as a general chemistry laboratory experiment around the world.[1] The purpose of the experiment is to determine the equilibrium constant of the reaction using a colorimetric method:

$$SCN^- + Fe^{3+} \leftrightarrows [FeSCN]^{2+}$$

We include this simple experiment in a latter course of the Physical Chemistry because it brings the opportunity to implement diverse topics, competences and activities in a "all-in-one" manner, namely:

- Determine the equilibrium constant under ionic strength conditions in which the values of the activity coefficients significantly differ from 1.
- Apply the scientific method.
- Improve experimental results by using an iterative calculation method.[2]
- Use efficiently spreadsheet packages to perform all calculations.
- Learn from calculated errors and analyse errors sources.

To meet these goals, we developed computer codes to carry out all calculations needed to evaluate the activity coefficients, equilibrium constant, and associated errors using an iterative method.[3] These codes are interfaced with an interactive web platform[4] that allows students to improve their tasks and also it ensures the correctness of the associated calculations. As calculation procedures become long, the web platform becomes a guide for the students to correct all intermediate values. The error associated with the determination of each magnitude is calculated by our codes, so this allows us to correct each individual value introduced by the student in the web platform.

Moreover, since we collect the results in a database yearly this provides the basis for an objective statistical evaluation tool for the teacher,[5] who can use the accumulated data to evaluate the goodness of the value for the equilibrium constant and its error.

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Developing and Implementing an Innovative Digital Template for Research and Design Projects in Academic Science Education

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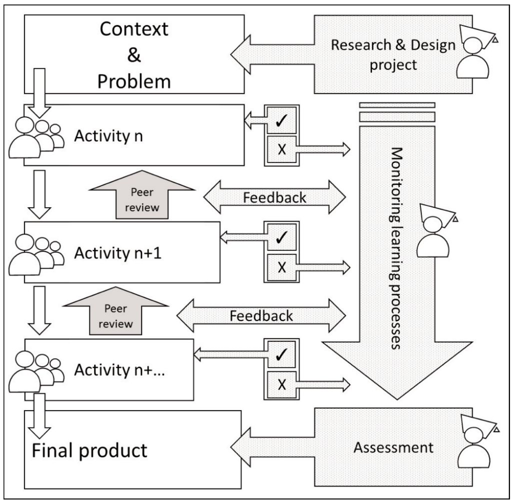
Introduction

Although lectures and seminars are still the main teaching methods in academic science education, teachers experience these methods as moderately effective to achieve the desired students' learning outcomes regarding research and design skills. Implementing research & design projects (R&D projects) would be more effective. However, teachers struggle to implement these projects in large heterogeneous student populations. Besides organizational difficulties, compared to current teaching practice teachers need to develop different competences. Modern technology could support teachers in developing and implementing R&D projects in their courses. To support teachers in developing and implementing R&D projects in large heterogeneous student populations, this project aimed to develop a digital template as a tool kit for monitoring and assessing (both formative and summative) the learning processes of students regarding the development of research and design skills

Development and implementation of the digital template

We developed an educational framework for R&D projects based on principles of current innovative teaching models such as inquiry-based learning (Brew, 2003), problem-based learning (Pease & Kuhn, 2010) and context-based learning (King & Ritchie, 2013). Based on this framework a coached community of teachers and educational developers develop the digital template. The template will be implemented in two second year courses in which 60 undergraduate students from different tracks in science education participate.



Evaluation and results

The development and implementation of the template will be evaluated by conducting a qualitative case-study analysis (Creswell, 2007) focussing on: 1. teachers' development of competences in developing and implementing R&D-projects; 2. students' learning processes and outcomes regarding R&D-skills; 3. the development and implementation process of the template; 4. teachers' and students' perspectives on the influence of implementing the template on students' learning outcomes. The results of developing the framework and template will be presented at the conference.

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The change of functionality – The development of chemical synthesis since the days of alchemy

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The study of the history of chemical synthesis – in contrast to chemical analysis – is quite uncommon, although it plays an important role in the development of chemistry as a modern natural science. The poster will show the different functionalities of chemical synthesis throughout the course of time using five case studies to show its historical development. The main question is: What does the development of chemical synthesis since the days of alchemy demonstrate for a better understanding of the history of chemistry? And what is the relevance of chemical synthesis in the progress of chemistry as a modern natural science?

The theoretical background for the consideration of these historical steps lies in the epistemology of Gaston Bachelard [Bachelard, 1987] and Georges Canguilhem [Canguilhem, 1979]. The case studies deal with 1. the role of synthesis in alchemy (1599), 2. the work of Lavoisier (1789), 3. the work of Berthelot (1877), 4. the first adrenaline synthesis at Hoechst, a German chemical company (1906) and 5. the role of synthesis on the basis of the material nylon (1935). They show an erratic development of the understanding of synthesis as a holistic and spiritual principle to a method that is capable of producing artifacts in several ways. In addition, this research-project reveals five different concepts and ideas of matter behind the functionalities of chemical synthesis. Furthermore, it shows how a scientific method can be used in various ways. The various uses of synthesis throughout the history of chemistry can also be used to establish the plurality of a scientific worldview. This investigation of the history of science is important and helps to acquire both a better understanding of the development of chemistry throughout the course of time as well as the modern synthesis concepts in their uses and functions and therefore offers an interesting perspective for those who are teaching chemistry.

Turning your spreadsheet into an always updated chemistry handbook

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Abstract

The availability of chemical data has grown exponentially in the lasts year. Chemical databases like PubChem and ChemSpider and general encyclopedias like Wikipedia make it readily available for general users. Now that spreadsheets can access them, will they be the new handbook?

Communication

Online chemistry databases like PubChem and ChemSpider have more chemistry data than most handbooks. Furthermore, easily accessible APIs are available for these and other services that allow computer savvy chemists to collect and process this information in convenient ways.

Another service that contains an ever-growing amount of chemical information are the Wikipedia which may be one of the easiest places where to find values for different molecular properties. Nevertheless, Wikipedia also is an easy way to find the translation of chemical names.

In parallel, the last versions of the most common spreadsheet editors (Microsoft Excel and Open/ LibreOffice Calc) have incorporated some new functions that allow accessing webs and web services to be accessed from simple formulas. The downloaded information can then be processed with standard Excel functions.

In this communication, we present how to use the chemistry web APIs and these spreadsheet functions to make an alternative to a chemistry handbook, with some advantages: it's light, free and always up-to-date.

The Impact of School Field Trip on Students' Environmental Awareness towards Plastic Pollution

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Plastics have become the indispensible material in the modern society. They have the widespread uses in various fields like plastic bottles, supermarket bags, cosmetics, food and drinks, construction. Unfortunately, within the last 30 years, scientists have realized that the useful attributes of plastics are what also make them detrimental to our environment (Sigler, 2014). Because of their low degration rates plastics act as pollutants, they adversely affect the environment and pose serious environmental pollutions that may persist for centuries.

Despite the increased international attention, the build-up of plastic materials in the environment is considered problematic due to the increasing global plastic production (280 million tons per year in 2011) (Plastics Europe, 2012) and the continuing improper disposal of plastic waste (Van Cauwenberghe, Vanreusel, Mees & Janssen, 2013). The potential ecological and human health risks of plastics are a new area of scientific research, and there is currently a large degree of uncertainty surrounding this question and relatively few studies aimed to educate the high school students about the ecological impacts and risks of this emerging plastic pollution, particularly in the seas and oceans.

This current study aimed to investigate the effects of a field trip to a coast at the Black Sea region in Turkey on the environmental awareness of students towards plastic pollution in the seas and oceans. Six participants of this case study made observations and collected the plastics during their field trips, documented the presence of plastics and shared their observations about the impacts of plastics with their peers in the school community by making presentations. Before and after the field trip, as well as after they completed their presentations students were interviewed. The interviews were coded and analyzed, though open-coding. The preliminary findings suggested that students' environmental awareness raised by the inclusion of the field trip about the plastic pollution and this type of field trips should be concern of all educators in order to develop positive attitudes among the students on the environmental issues.

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Personal Construct Psychology (PCP) as a theory to inform a proposed Model of Learning

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(Gilbert 2005) highlights that models of psychology and their implications, such as that of George Kelly (1955), should be considered regarding science education. In his theory, (Kelly 1955/1991) refers to the assumption of 'opposites' such as that of positive ***versus*** negative regarding the atom, as important. Fransella (2016) asserts that chemistry may be viewed as sharing with PCP the inherent assumption that people think in terms of contrast. An alignment also exists between 'chemistry education' and PCP. For example, Clement (2008) notes that efficient mental models usually embrace the inter-relationships within a system ***versus*** a collection of isolated facts. Cracolice et al. (2008) state that a very low percentage of students in junior secondary school possess sufficient reasoning skills. In this regard, Gabel (1999) considers the *Information Processing Model* of learning as important. Potentially, a related cycle that may be used to consider what constitutes learning is Kelly's ***Experience Cycle.*** Pope and DeNicolo (2001) acknowledged the vital role of '*permeable*' constructs in the elaboration of understanding. In this paper a set of such constructs are offered within the context of the ***Experience Cycle.*** It is hoped they might be used as axes to assess learners' progress and to gauge potential appropriate teaching responses to the learning status of concepts in the classroom. Within this approach, the dichotomous nature of constructs is employed to ***measure*** key ideas such as utilising students' views as starting points and resources (Taber and Franco 2009). It may also assist in the metering of student implicit knowledge elements (Talanquer, 2014). Hence, it is hoped that PCP will provide a framework that allows teachers to improve the reasoning skills of their students and thereby serve as a bridge builder between theory and practice. A model of learning that reflects this bridge is illustrated.

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Teaching Chemists Crystallography – Modern or Obsolete?

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X-ray crystallography in recent decades made explosive development, routine data collection may be done in minutes and computational part in less than half an hour or so. This situation led, in many educational institutions, to the conclusion that crystallography may be considered as a standard tool not deserving any separate course. The present paper is devoted to discussion on the problem and, in particular, to the proper inclusion of crystallography to university curricula.

One of the serious mistakes associated with limitations of crystallography courses in chemistry is omission of teaching symmetry which typically is a standard and substantial part of classical crystallography classes. This is a very important problem in present chemistry education, our students need understanding of symmetry properties of molecules, supramolecules and solid state materials in order to comprehend the properties and their relations to the structure. Put in other words, the chemists may nowadays easily get structural information from x-ray labs without necessary understanding of it. Conclusion No. 1 is that modern crystallography curricula should concentrate on symmetry aspects of chemical structures, at different levels, i.e. from molecular to crystalline. And expand it as compared to the traditional, basic content.

Modern crystallography provides much more information than may routinely be used by chemists. It may be illustrated by means of dynamic parameters of the x-ray structure, represented in output files as the, so-called, ‚temperature factors'. This part of data is seldom used in chemical discussions since chemists usually do not follow the physical meaning of the relevant data. This situation could easily be improved by respective modifications of the curricula. This is conclusion No.2: we need to extend the content of physics of condensed matter in chemistry courses so as to provide the students with the basic knowledge on dynamics of atomic and molecular structures.

No. 3 conclusion is associated with enormous developments of special methods and techniques in diffraction: synchrotron sources with the possibility of time resolved structure analysis, neutron sources (spallation) for structure determinations of hydrogen in environments of heavy atoms, x-ray structure from powder diffraction, electron diffraction studies, investigations of low dimensional materials and many others.

The amount of crystallographic information gathered hitherto is enormous and growing at accelerating speed. In October 2015 the number of structures deposited in the Cambridge Crystallographic DataBase was 800 000 ! It is huge set of chemical information, let our chemists be able to follow it and make a competent use of it.

The conclusions mentioned above point towards importance of crystallography teaching at novel level, answering questions arising from modern chemistry like supramolecular, low dimensional materials etc. We might call it 'symmetry and structure of chemical systems' if a replacement of the term 'crystallography' is preferred. And it would reflect the modern characteristic of this subject, in contrast to the traditional, descriptive concept.

Exploring General Chemistry Students' Cognitive Abilities and Domain-Specific Skills in the Context of Stoichiometry

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In this study, a group of general chemistry students' cognitive abilities and domain-specific skills were compared by analyzing their performance on 25 stoichiometry questions. To better understand the reasons behind students' failures and achievements, they were grouped as higher- and lower-achieving students based on a diagnostic test; similarities and differences in the students' performances, strategies, and mistakes were investigated. The study revealed that the major difference between higher- and lower-achieving students lies in their cognitive skills, especially in domain-specific (mole concept) skills and their ability to deal with complexity. Results suggest that a thoroughly differentiated set of tasks be applied in the undergraduate chemistry classroom when possible: tasks with limited complexity and structured help or scaffolding are needed for lower-achieving students, whereas complex and abstract tasks are needed to challenge the higher-achieving students.

Monitoring Authentic Chemistry Problem Solving with the Eye-Tracking Method

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When learning chemistry concepts it is important to address three levels of presentation: (1) the macroscopic (2) the sub-microscopic and (3) the symbolic level, based on their visualization (Johnstone, 1991; Devetak, Vogrinc and Glažar, 2010). According to the research more than 80% of the population receive and process information using the visual channel (Chuang and Liu, 2011). There is significant correlations between the cognition process and eye movements. Monitoring the eye movements allows for determining the located point on the object, perceived by the eyes. When a person has established the focus of his highest greatest attention on the observed object, fixations (a condition when the macula is stabilized on the observed object) can be used to denote the centre of directed attention, which is of major interest to the individual. The number of fixations is thus associated with the number of the information parts, which the individual simultaneously processes. The fixations usually last from 200-300 milliseconds, whereby each of them is separated by a saccade (a state of rapid eye movements into the centre of interest, which brings a new part of the visual scene) (Duchowski 2002; Chuang and Liu, 2011; Meng-Jung, 2011).

The purpose of the study is to develop the methods for monitoring cognitive processes at solving the triple nature problems of chemistry concepts through the use of an eye tracker. The study involved teachers, primary school students and secondary school students, who were solving seven authentic chemistry problems related to the states of matter and chemical reactions of burning. The data, which will be qualitatively processed on a sample of 10 pupils, 2 students and 6 teachers, were audio and video captured. The participants completed the questionnaire after each authentic problem in which they evaluated the solving process. The problem displayed on the computer screen contained the photos of the phenomenon/process (the macroscopic level) and the animations of the particle movement (the sub-microscopic level) along with the task instructions and questions. In the problem related to burning the equations of chemical reactions were also included (the symbolic level). The conclusions will be used to optimize the authentic problems, which will be used for the identification of the problem solving strategies in the second part of the research.

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Students' focus on 2D and 3D images of molecule models when solving simple chemical tasks

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Different models with their advantages and disadvantages can cause different misconceptions when using them during learning chemical concepts at submicro level (Justi, Gilbert and Ferreira, 2009). Research also show that the best learning results can be accomplished using a multimodal learning approach–a combination of various types of models and different modes of representations (Wu and Shah, 2004). Nowadays analysing eye movement behahavior is offering a promising method for further investigations in this field (Havanki and VandenPlas, 2014).

This research examines which static 2D or 3D molecular models students use, when solving simple chemical tasks, where both model types are equally useful for answering the questions. For this propose four research questions were asked: (1) Where do students focus when simultaneously shown 2D or 3D types of models with no specific task to solve? (2) When given 2D or 3D types of the models, where do students focus when asked to solve specific task? (3) Is there a significant difference between students' focus on specific type of the model before and during solving the task? (4) Does students' interest in chemistry influence their focus on specific type of model when solving the task?

27 students participated in this study. Two instruments were used to measure students' interest in chemistry and their pre-knowledge about specific chemistry concepts. To determine the degree of visual attention directed to the static images of 2D versus 3D models screen-based Tobii X60 eye-tracker was used, which recorded the location and duration of eye fixations at rate of 60 Hz. After calibrating the eye-tracker, the participant saw two images of 2D and 3D models of the same molecule for 2 s. After that, the task was displayed below simultaneous presentation of both representations of a molecule. Half of the 2D images were displayed on the left and half on the right. Each item was presented for an unlimited duration. For comparison purposes the percentage of students' eye fixation time on each type of model was calculated. Longer fixation time on one type of representation relative to another type was interpreted as students rely more on that type of representation when solving the task.

Results show that students before the chemical task focus more on the image that is displayed on the left side, but while solving the task they focus more on 2D models. There is a difference between students' focus on specific images before and during solving the task – focus on the 2D model increases. This difference is significant in most cases. It can be also concluded that students with higher interest in chemistry focused more on 2D models during solving the chemistry tasks, than students with lower interest in chemistry.

Short abstract:

This research examines which representations–static images of 2D or 3D molecular models students use when solving simple chemical tasks, where both model types are equally useful for answering the questions. It can be concluded that students before the appearance of a chemical task focus more on the image that is displayed on the left side, but while solving the task they focus more on 2D models.

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Contemporary Science in chemistry teacher education – An empirical study

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In relation to current research students who are going to be chemistry teachers in Germany often don´t study chemistry in sufficient depth. This is sometimes advocated by the fact, that school curricula seem to reflect the status of chemical knowledge up to the 1950s. By contrast new teaching strategies like context oriented approaches [1] tend to include modern aspects of chemistry in the classes and a 2008 study [2] shows that the higher the expert knowledge is, the higher the skills for teaching are. Our research project therefore focuses on the professional development of chemistry teacher students in relation to today's chemistry research. The main question is: Does the professionalism of students studying chemistry education change if they are confronted with today's research?

The study is developed on the theoretical basis of Shulman's concept of teacher professionalization [3], with a focus on Subject Matter Content Knowledge and Pedagogical Content Knowledge, including a third dimension, Beliefs. The three categories will be examined under consideration of the competence-orientated theory [4] following a mixed methods approach of quantitative methods (questionnaires, tests) and qualitative methods (interviews, discussions). The poster will show the genesis and the structure of the research project, give an insight into the test instruments and the concrete categories of the qualitative analysis and will show first results.

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Primary school teachers' beliefs about learning in science and their according action in the classroom

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Teachers' planning and action in the classroom is amongst other things influenced, regulated and mediated by their intentions which consist of individual pedagogical, content and pedagogical content knowledge formed throughout professional development and teaching experience. Beyond knowledge, teachers are strongly influenced by individual beliefs that are evolved since childhood development (Haney, Lumpe, Czerniak, & Egan, 2002; Pehkonen & Pietilä, 1996). In unsecure situations teachers personal beliefs might mediate their action and bestride professional knowledge (Haney et al., 2002). This study deconstructed the underlying beliefs of seven primary school teachers concerning science education in a long-term case study design. The data was analyzed with Grounded Theory. Therefore, classroom videography and individual interviews have been repeatedly conducted twice a year over a period of two years. The results show vividly that the teachers believes about science education in general and about primary school learning differ from scientific educational positions and the teachers action in the classroom is according to their own beliefs.

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School-university partnership: a potentiating tool to reflect on the teaching practice

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By attending Chemistry classes of newly trained teachers, undergraduates of the same course observed that old practices were still being used. Although the discussions showed theoretical-practical fragilities in undergraduates and teachers, satisfactory results were obtained with the high school students when a different proposal was employed.

Over the years, the relationship between the institutions responsible for teachers' initial training and basic education, especially public ones, has been predominantly characterized by the mismatch and distance[1]. This is due to the technical training model in which great part of Brazilian teacher training courses are based. In this case, the Institutional Scholarship Program to Teaching Introduction (PIBID) offers initiation scholarships to enable students that are dedicated to the internship in public schools. The goal is to anticipate the link between future teachers and classrooms of public schools, thus reducing the distance between these two realities. This study aimed to analyze the training process throughout the Chemistry degree course, targeting students of Federal Institute of Rio de Janeiro (IFRJ-Duque de Caxias). Considering that teachers are multipliers and that teacher education can be a bias of social transformation, this work was done with two groups: undergraduates and graduates of the course, who teach in public schools at Rio de Janeiro.

Therefore, a group of 06 undergraduates attended classes of 03 teachers, who graduated at IFRJ. Two of those teachers participated in the PIBID during their degree course. Throughout the lessons they noted the teachers' strategies and practices and the students' reactions to them. At the end, the undergraduate students, with the teachers' help, proposed an activity, which included the exhibition and a discussion of the video "Chemistry: all about you" [2]. Despite the fact that the teachers had an alternative initial training, which focused more on the form than the content, it was observed that they were still using old practices. As a result, most students appeared to be disheartened, although they had appreciated the effort and good will of teachers. In addition to that, teachers' resistance to implement an unconventional approach in their lessons was observed in several discussions. One of their main arguments was the negative reaction that the students could have forward the proposal and the lack of time to fulfill the established content. However, the proposal was well accepted by the high school students, who participated effectively. During the application, the teachers were satisfied and noticed that their students responded well to the proposal incentives. It was also observed that both undergraduate students and teachers have some fragilities in chemical contents, and difficulties in theoretical-practical mediation.

The results reinforce the potential of a dialectic proposal to work with the undergraduate and graduate students, keeping in mind that using non-conventional approaches in the Chemistry teaching is an efficient way to reflect upon teachers' roles as citizen formers.

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Professional teaching competencies and didactical models of beginning teachers in sciences.

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Abstract

The current work incorporates the results of a project where a group of teachers were analyzed in order to search the existing relationship between the professional teaching competencies (PTC), the didactic models and the perception of the university formation they received.

The didactic models are structured plans to configure a curriculum, in the design of materials and, more general, to guide the teaching process (Jiménez, 2000). In the student learning process, the teacher's didactic models have great importance, as they are a mediator system between the reality and the thoughts (Chrobak, 2006). Based in the analysis of five characteristic dimensions, García (2000) elaborated the following classification: W***hy to teach? what to teach?, student's ideas and interest and how to teach and evaluate***, thus resulting in different didactic models. The characterization of a didactic model supposes the selection and the study of the principal aspects associated to the teacher's thoughts and the educative practice.

On the other hand, some researches show that the beginning teachers with more years in the field still employ the traditional teaching practices based in the oral transmission of the contents, which considers a rigid and non-problematic vision of the science. This behavior evidence that exists a strong similitude in the practices of the teachers in the initial formation, respect to the formation that they received from their university professors (Mosquera 2012). From this perspective, we propose the existence of a relation between the didactic model and the professional competencies that science teachers develop in the classroom. It is for that reason that it is interesting to inquire on the professional practice of the beginning science teachers, in function of what Perrenoud (2005) define as the ten new competencies for teaching, which are considered as a high priority in the continuous formation of teachers. From this implicit link, it is essential to ask ¿What it is the relation between the didactic model, the professional teaching competencies of the beginning science teachers and the initial formation received, manifested in the teaching of formal concepts? The goal is to establish relationships between the formative processes and the professional practice, contributing thus to strengthen the initial formative processes of teachers in our country. Initially, a mixed study was made, descriptive-interpretative, for obtaining the information of the didactic profile and the PTC of the participants teachers, to access later by an interview to the perception of themselves about their own formation. This study is focused on beginning science teachers: biology, physics and chemistry, graduated at the same university and exercising the profession.

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Comparison of two digestion methods for the analysis of metals in different sample matrices by chemistry undergraduate students.

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Short abstract

Two methods for the digestion of organic and sediment samples, were implemented and validated as laboratory experiments for chemistry students of the sixth semester at the University of San Carlos, who could compare the results obtained with both methods, getting involved in a validation process and observing the processes inside the reactor.

Abstract

Students of the sixth semester of the course of chemistry at the University of San Carlos of Guatemala perform basic analytical research work as part of their practical formation. One of the recent experiences is the comparison of a method of digestion using a Hach reactor (Digesdahl(R))[1] with sulfuric acid and hydrogen peroxide and other method using a Milestone Microwave digester with the use of nitric acid and hydrogen, as sample preparation for metals determination. Sediments collected in a Guatemalan lagoon which receives industrial effluents from a shoes factory were digested by both methods. The methodology was validated using a sediment reference certified material for toxic metals. Organic reference certified materials were also digested by the two methods to evaluate the results.

The digestions of organic matrices needed less mass and reagents than the sediments digestions, giving clean and colorless solutions, meanwhile the solutions from sediment digestions were slightly colored, with undissolved silicates which were separated by filtration prior to the analysis by Atomic Absorption Spectroscopy (AAS).

The main variable for the comparison of the methodologies was the time of digestion, thus different times were experimented, trying to optimize each step to get a clean solution. The digestions done in the reactor were critical for the learning of the students, generating expectations and allowing the students to observe the processes that occurred inside the reactor, as the generation of fume and the system internal pressure. This is important for student learning, as the microwave digestions occur in a closed system not allowing to observe the process and to acquire new skills.

Although reactor digestions take longer than the microwaves assisted ones, they are an important resource for teaching a relatively low cost digestion method for the future chemists.

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Implementation of an experimental procedure for the extraction and analysis of volatiles from a Guatemalan aromatic plant by SPME.

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Short abstract

An experimental procedure for the extraction and chromatographic analysis of plant volatiles by hydrodistillation and SPME was implemented at the laboratory by chemistry students. After the analysis of *Stevia serrata* volatiles, they compared and discussed the analyte selectivity and composition results by the two methods and by different SPME sorbent materials.

Abstract

The Curriculum of the career of Chemistry at the University of San Carlos undergoes modifications almost every ten years. As a part of the last curricular update carried out in the year 2000; elective courses were created for the ninth and tenth semesters in an attempt to improve the professional development of future chemists in different areas. One of these elective courses is the course "Modern Methods for Sample Preparation" which has been attended for undergraduate chemistry students who want to get involved in research and in analytical chemistry.

The course has incorporated different analytical methods implemented through research projects mainly of Environmental Analytical Chemistry and Natural Products Chemistry. One of the methods which has been successfully implemented for the aquisition of new knowledge and skills by the students is the analysis of volatile natural products from Guatemalan aromatic plants using Solid Phase Micro-Extraction (SPME) and Gas Chromatography (GC).

The experimental procedure to be presented at the Conference is the comparison of the composition of the essential oil extracted by hydrodistillation and the volatiles extracted by SPME of ***Stevia serrata***, an aromatic plant from the western highlands of Guatemala. The composition obtained by SPME using PDMS sorbent material were similar to that obtained by hydrodistitllation of the essential oil, showing nearly 60% of chamazulene, a substance which has anti-inflamatory properties[1]. The students also evaluated how the composition of the solid phase influences the selectivity for different analytes, choosing the one which extracts volatiles in a similar proportion to hydrodistillation. The students carried out by themselves the sample preparation and extraction physical processes. They reviewed the SPME and analytical procedures, discussing the advantages of using this extraction method for the rapid screening of vegetal material for quality control processes, and studying the applications of the method in other materials.

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"Locus: A real adventure": an RPG (Role-Playing Game) as an alternative instrument to promote citizenship and environmental education

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A humanistic, transformative Chemistry curriculum must confront the emphasis on the technological development and bring the discussion about the role of people in decision taking. A game dealing with acid rain was developed in order to promote social reflections among the students while making decisions based on chemical concepts.

In our business-driven world that overemphasizes technological development and that sees the human being as a victim of forces (Rogers, 2012), the humanistic philosophy contradicts the notion that the individual is but a link between a number of complex causes and their inevitable and predetermined effects. According to Aikenhead (2005), "a humanistic science curriculum is transformative, in that it nurtures, at the very least, the development of critical position towards science and technology".

Therefore, the teacher must become the mediator between the knowledge imparted in the classroom and everyday situations. For such, the teacher needs to create situations that allow students to express themselves freely, to work real situations in order to create a meaningful learning and to use alternative assessment methods.

In recent years, games have been used as a tool to check chemical concepts. Considering the three levels of chemical knowledge defined according to Machado (1995) as phenomenological, theoretical and representational, games may help teachers in the process of evaluating these skill levels. Moreover, educational games are an alternative to traditional classes which students complain very often. Thus, we decided to develop a RPG (role–playing games) to discuss the chemical concepts related to acid rain based on an interdisciplinary approach and on decision taking steps by students, in order to reinforce the initial idea to develop a cooperative game.

The game is called "Locus : A Real Adventure" and it is an educational RPG and board game. The game is set in Locus, a country located in Sorkram planet, which has five provinces that are suffering with problems caused by acid rain. To solve problems, students are required to take decisions, based on simple chemical experiments and/or questions that require them to go through the five existing provinces in order to solve the problems, but taking also into account the social and economic consequences of their decisions.

The game was presented at the Second Workshop of Didactic Games of the Laboratory of Didacticts of Chemistry (LaDQuim) of the Federal University of Rio de Janeiro, which was attended by 24 teachers that evaluated this RPG through a questionnaire based on the Likert scale.

The results were that 95.8 % of teachers were favorable or strongly favorable to the concept that the game deals with interdisciplinary issues and that it simulated a real situation that could be related to the discussion of topics usually taught in their classrooms. In addition, 87.4 % agreed that the game can be used as a motivator for the students, and 70.8 % believed that it could be used as an evaluation instrument of the chemical contents. Finally, 87.5 % believed that the use of experimentation was relevant throughout the game. It is also interesting to note that 92 % of teachers had never played a role-playing game.

This way, we verified that this RPG was well accepted by teachers, even as an assessment activity. Furthermore, all teachers agreed that it is a cooperative game that attends the premises of the STS approach for scientific education.

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keywords

STS, Acid rain, Teaching, Citizen Education.

Synthesis of Novel 2-heterostyrylbenzimidazoles as Potential Anti-tuberculosis Agents: A Scientific Approach

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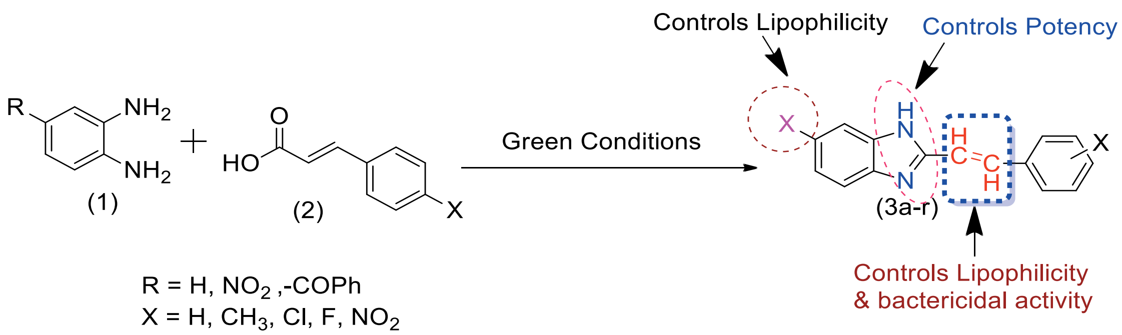
Tuberculosis is one of the oldest documented infectious disease and threat to worldwide public health, mainly caused by ***Mycobacterium tuberculosis (M.tb.)*** bacteria species. It is the only disease that does not require any vector for transformation from one person to another[1]. In 2010, there were around 8.8 million incident cases of TB, and around 1.1 million deaths from TB among HIV-negative people, and an additional 0.35 million deaths from HIV-associated TB [2]. The active TB is currently treated with a four-first-line-drug regimen comprising mainly isoniazid, rifampicin, pyrazinamide, and ethambutol for a period of at least 6 months [3, 4]. However, the disease has been undergoing resurgence in the last two decades driven by variety of changes in social, medical, and economic factors as well as ***M. tuberculosis*** resistance to the aforementioned drugs itself. The resurgence of TB is now one of the most serious public health concerns worldwide. Despite its global impact on world health, TB is considered a neglected disease, and no new anti-TB therapeutics have been introduced into the market over the last half-century. The last drug with a new mechanism of action approved (rifampicin) was discovered in 1963 [5]. Therefore, there is an urgent need for development of new drug leads to combat this chronic infectious disease.

Cinnamic acids, its derivatives such as ethyl cinnamate, sodium cinnamate, and benzylcinnamate have century old history as potential antituberculosis agents. 2-Styrylbenzimidazoles which were synthesized from these Cinnamic acids are also showed promising antituberculosis activity, but the practicable greener routes available for the synthesis of novel 2-heterostyrylbenzimidazoles are very less in the literature. Herein, we report the facile synthesis of some novel 2-heterostyrylbenzimidazoles using greener routes which were tested against ***Mycobacterium Tuberculosis*** and other Gram positive and Gram negative bacteria.



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A didactic sequence to explore socioeconomic issues of modern africa in chemistry education

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A Brazilian law that obliges teaching of African culture and history created an opportunity to develop the criticism of students, using scientific and technological innovation concepts to analyze Congo's War and to inspire them to propose transforming actions. The results obtained reinforced the potential of integrating social and chemical issues.

Chemistry teaching should not be based on students' passivity and memorization and should contribute to develop their critical role in society. The knowledge built in the classroom needs to be used by students to support and encourage their decisions, and inspiring transforming actions (SANTOS; SCHNETZLER, 2010). In this direction, the Brazilian Federal Law 10.639/03 establishes the obligation of teaching Afro-Brazilian and African culture and history in all educational institutions in Brazil (BRASIL, 2003). Making students more distant from an Eurocentric conception of certain ethnic groups also means an important contribution to their ideological education. It enables students to recognize and appreciate their own culture (MOREIRA et al. 2011). Therefore, this paper presents a didactic work done with students with whom scientific and technological innovation concepts were used in relation to the Congo's War in Africa.

This study began with a presentation pointing the positive aspects of some scientific and technological innovations. Then, the documentary "Blood in the Mobile (2010)" was exhibited. A discussion about the positivist and impartial approaches to scientific aspects was held subsequently. In this case, the social aspects of the Congo War and the role of students as individuals in a consumer society were explored. At the end of the discussion, students were asked to establish relations between what was discussed after the documentary and their roles as chemistry teachers.

At the end of the proposal, the development of the following points was frequently identified:

- The teacher needs to provide students with situations where chemical contents are addressed relating them to cultural, historical, political and social discussions.
- The main chemistry teaching goal should be to make students take ownership of the content to enable them to use it in a transforming perspective;
- It is necessary for students to identify their role within society ruled by consumerism and immediacy, in order to enable them to be reflective and critical citizens. The results of this study reinforce the potential of working with social issues in a culturally guided form and integrating it with chemical aspects

The results of this study reinforce the potential of working with social issues in a culturally guided form and integrating it with chemical aspects, which are considered a curricular requirement in the educational process and an essential tool in building citizenship.

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keywords

STS Education, African culture, Education for Citizenship.

Integrating the essential nanoscale science and technology (NST) concepts in high school chemistry curricula in Israel

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Abstract

The goal of the current research is to identify the insertion points of the essential nanoscale science and technology (NST) concepts in the high school chemistry curriculum in Israel.

Background

Several reviews about nanotechnology education (e.g., Jones et al., 2013) highlighted the need of providing guidance for integrating NST into high school science curriculum. This includes: identifying the concepts that should be taught in high school science, identifying the insertion points of these concepts within the school science curricula, among other things. Based on our previous studies regarding the essential concepts and applications of NST(Sakhnini & Blonder, 2015; Sakhnini & Blonder, 2016) we decided to determine the insertion points of the NST essential concepts in the high school chemistry curriculum in Israel for applying our research results to the educational field. This study will serve as an example for integrating NST concepts in high school chemistry curriculum in general.

Research participants, tools and design

Eleven experienced high school chemistry teachers participated in the research. They underwent a new designed course that included the NST essential concepts. After learning the NST concepts the teachers were individually asked to find insertion points for each concept in the chemistry curriculum. Then, a discussion was held during the next lesson in which the teachers were able to clarify their ideas of integrating the essential concepts in the curriculum and to share them with their colleagues and the research team. A validation process was conducted one year later in which 25 high school teachers participated in an online "introduction to materials and nanotechnology" course that was built of short videos about the essential NST concepts (Cohen, Blonder, Rap, & Barokas, 2016). The teachers who took the course were also asked to suggest insertion points of the NST concepts to the chemistry curriculum. In addition, for each concept they were also asked to give an explanation why they think the concept is suitable to be integrated in the suggested insertion point. Their suggestions were compared to the primary process described above.

Analyses and Findings

All the NST concepts were suggested to be integrated in high school chemistry curriculum. Some of them were suggested in several topics of the curriculum. For example the concept "size dependent properties" was suggested to be integrated in the topics: Basic concepts (e.g., melting and boiling point state of matter), atomic structure, structure and bonding, chemistry of food, kinetics, polymers, physical chemistry, biochemistry and inquiry laboratories. In the poster we will present the full integration map.

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Exploiting the responsible research and innovation dimensions in science education–results of the engage project

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Short Abstract

The paper introduces the ***ENGAGE Project*** and its main results emphasized at national level, materialized mainly in face-to-face workshops / on-line courses ("***Methods of promoting RRI dimensions in science education***"), having science teachers as participants, where several interactive-participatory teaching strategies are presented and experienced.

Content

As a paradigm which has been already understood as an umbrella that gathers together various aspects of the relationship between science and innovation and society, ***Responsible Research and Innovation*** (***RRI***) becomes an issue embraced by many researchers and exploited in several European research projects with the aim to make people and institutions sharing the responsibility for building the future, through an active involvement of the societal actors in the process of research and innovation. Specific key aspects of RRI have been defined since 2011 by Sutcliffe (engagement, gender equality, science education, ethics, open access, governance), but they have been divided by the ***Expert Group on Policy Indicators for Responsible Research and Innovation*** (2015) into three sections: (I) ***good governance***–as an overarching principle for ***R&I networks***; (II) ***public engagement***, ***gender equality***, ***science education***, ***open access*** and ***ethics***–as the five main keys for governance; (III) ***sustainability*** and ***social justice***/***inclusion***–as a more general policy goal.

But how those key-issues can be implemented in science education? An answer comes from the exploitation of the integrated dimensions of RRI, presented by Stilgoe et al. (2013): (I) anticipation–previsioning the future; (II) reflexivity; (III) inclusion–involving various stakeholders in science and technology development; (IV) mutual responsiveness. In this respect, the European FP7 project called ENGAGE tries to increase the attractiveness of the science lessons, by promoting interactive-participatory teaching strategies, based on involvement and reality investigation, identification and testing of alternative solutions, in order to make the young students to think and apply their scientific knowledge, followed by taking / assuming responsible decisions. Challenging issues, everyday-life situations and relevant scientific subjects are enframed in didactic scenarios, with the view to raise the students' knowledge, to introduce and operate with the concept of RRI, but also to make them aware of its relevance in the actual society. Modules like: ***Ban Cola***, ***Ebola***, ***Zika***, ***Eat Insects*** and many others, offer also to teachers the possibility to find out how to design a teaching demarche based on an actual dilemma, and also how to initiate the students' debates, in strong relation to RRI dimensions, especially on moral, ethical and social issues.

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Cheminformatics olcc: teaching a class on cutting-edge digital technologies across multiple campuses

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Abstract

The last OLCC was on the topic of cheminformatics. In today's interconnected world data is readily accessible online, and skills in cheminformatics data acquisition and manipulation are critical for tomorrow's STEM workforce. This poster will describe both the 2015 cheminformatics OLCC and the upcoming Spring 2017 reedition of the course.

Communication

Cheminformatics is a vast and complex subject. While classical cheminformatics evolved out of the pharmaceutical industries, in silico medicinal chemistry, the ability of computational software to predict chemical properties and the need to manage large chemical data sets, cheminformatics has also been changing the fundamental cognitive artifacts used by practicing chemists to represent, manipulate and communicate chemical information. The amount of chemical data existing in digital formats is growing every day. Large public databases like PubChem, ChemSpider and Wikipedia make data readily available on an international scale, and yet few schools are equipped to teach their students the latest technologies on the use of these resources. Thus this On-Line Chemistry Course (OLCC) on Cheminformatics was proposed.

OLCCs are hybrid courses sponsored by the ACS Division of Chemical Education's Committee on Computers in Chemical Education, where online guest lecturers collaboratively teach with residential faculty facilitators a class on a topic the facilitator would not normally be able to offer. The first OLCC was 20 years ago in 1996 making it one of the oldest online chemistry courses ever taught.

The Fall 2015 OLCC on Cheminformatics was structured into the following modules:

1A. Finding Information for Research in Chemistry
1B. Collaborative Citation Management
2. Information Science for Chemists
3. Data Management Best Practices
4A. Communicating chemical structure with formulas and names
4B. Communicating about chemical structure on computers
5. Chemical Identifiers
6. Comparing and Searching Chemical Entities
7. Representing and Managing Digital Spectra
8. Interacting with Databases: Desktop and Web based Applications

We are currently evaluating the Fall 2015 offering and preparing the Spring 2017 offering, which will have multiple project-based activities and give students opportunities to work with staff scientists at public compound databases. Please contact us if you want to be part of the project! Further information is available on the OLCC website, http://olcc.ccce.divched.org/. You do not need to be a member of the ACS to participate and this is an international effort.

Discovering the liquid gold of the Mediterranean: A Chemometrical Approach to the study of olive oil.

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Keywords: Olive oil, Acidity, Fatty Acid Composition, Phenolic Anti oxidants, Instrumental Analysis**.**

In the Spanish educational system, students have to carry out a "Research Project" (RP) at the end of their secondary school studies. The RP is a tool where students are able to synthesize their learnings acquired during primary and secondary school, as well as putting into practise different procedures and developing general skills which will be applied in professional research jobs, such as planning gradual steps to solve a problem, summarizing scientific literature, programming experiments, learning laboratory abilities, discussing results and improving communication abilities. The general aim of the RP is to place the pupils in situations of learning in the field of research, working on a subject of interest emerging from their environment.

The present communication shows the RP of Iris Carretero supervised by her Chemistry teacher Mrs. Montserrat Mialet. The specific aim of this RP was to discover what is hidden inside this golden liquid known as olive oil. Many questions suddenly appear: which is its origin? How is its production process? Which are the properties of the olive oil? How is it possible to determine the composition of different virgin olive oils? Would it be possible to classify olive oil from different origins? Would it also be possible to determine adulterations in commercial olive oils? What kind of analytical techniques will be needed to do this? And, how do we apply data analysis to the results?

Scientific and agronomical literature in this field was analysed [1-5]. Then the experimental work was performed. A brief period in the "Mas Montseny" estate (El Morell, Tarragona, Spain) provided information on rural olive production and processing technology in the olive mills. A longer period in "Rubió Laboratory" (Castellbisbal, Barcelona, Spain) allowed the development of the necessary experimental techniques. It is known [6] that: (a) virgin olive oil is a functional food which, in addition to having a high level of monounsaturated fatty acids, contains minor components with biological properties such as phenolic compounds (b) olive oil quality is related to the chemical composition, its oxidative stability and sensory characteristics, and (c) these parameters are affected by climatic conditions, agronomic practices, olive cultivar, the degree of maturity of the olives and, finally, the parameters of the processing technology in the olive mills. Various experiments were planned in order to distinguish between the different olive oils according to their origin, olive cultivar and production process.

Various olive oil samples were selected (24): from the official PDO-Catalonia (11) (PDO, protected designation of origin), other PDO's (8), unknown origin (3) and authentication control samples (2). The studied parameters and the applied analytical techniques were: (a) acidity–volumetric analysis (b)Factor K/rancidity–UV spectroscopy (c) changes in fatty acids composition–IR spectroscopy (d)polyphenols–HPLC and (e) organic volatile compounds–GC/MS. The obtained results were analysed using suitable statistical methods (PCA, Discriminant and Cluster analysis). A discussion of the results and conclusions has been carried out. The applied analytical and statistical methods permitted the identification of the composition and the classification of the analysed oil samples according to their origin, cultivar olives, manufacturing procedure and authentication of the olive oil quality.

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Introducing Inorganic Ions Qualitative Determination Tests in Lower-Secondary School Elective Course Experiments in Chemistry

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Experimental work motivates students by encouraging interest in learning experimental skills, strengthen the chemistry teaching, it gives an insight into scientific methods in develop research approaches (Tsaparlis, 2009). It is important that the teacher explains the theory behind the experiment and connects it with students' everyday life. Such activities are meaningful to students and only if understood correctly experiments can contribute to the increase of their interest in learning chemistry (Lunetta, Hofstein and Clough, 2007). In Slovenian lower secondary school students can participate at the elective subjects besides compulsory ones. The main goal of elective subjects is to enable the students to consolidate and deepen their knowledge and skills in the areas of their interests. In the field of Chemistry, schools offer three elective subjects, Experiments in Chemistry, Chemistry in the Environment and Chemistry in Life.

This research examines whether inorganic ions qualitative determination tests are appropriate for application to the Experiments in Chemistry, and how they influence students' interest in extra and in-depth chemistry knowledge. Some experiments for determining inorganic ions (e.g. chlorides, sulphates, phosphates, alkali and alkaline-earth ions) from the analytical chemistry point of view; qualitative analysis (e.g. precipitation reactions and spectrophotometric methods) of specific inorganic ions were designed.

The causal non-experimental method of empirical pedagogical research was used, with a pre-post research design, in which the questionnaires, knowledge pre-test and test were applied. 64 students of 8th and 9th grade of lower secondary school (13 and 14 years-olds), attending the course Experiments in Chemistry participated in this study.

On the basis of questionnaires »Understanding of Learning Content«, »Attitudes towards Chemistry«, »How I Study Chemistry?«, »How I See Today's Chemistry Lesson«, a knowledge pre-test and test, and a observation list, it was being determined whether the selected experiments are designed in a way that help students understand the instructions and the purpose of the experiments, whether the attitude towards chemistry and study preferences influence the students chemical knowledge, if the experiments influence students situational interest, and whether the experiments can be applied in one lesson.

Results show that the selected experiments for determination of inorganic ions are designed in a way that the students understand the instructions and the purpose of the experiments and that these experiments can be applied during one lesson of the elective subject Experiments in Chemistry. It was also concluded that attitude towards chemistry affects the analytical chemistry principles knowledge, while the students' study preferences have no effect on their knowledge. The selected experiments also positively affect the students' situational interest.

It can be concluded that the experiments for determination of inorganic ions are suitable for elective chemistry subjects and that they contribute positively to students' interest in chemistry as well as enhance the understanding of selected concepts.

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The atomic force microscope AFMone® as clearly arranged self-activity Access to nanomaterials in teacher education

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Today, nanotechnology is of great importance for science, industry and everyday life and it will become even more important in the future (Bradley 2010, Roco 2003). However, regardless of its importance, only a few aspects have been didactically conceptualized and considered for chemistry education yet. Furthermore, the results of several studies concerning students' specific knowledge on 'nano' show that this topic has hardly found its way into German schools (Wilke & Waitz 2012). One reason might be that teachers are unfamiliar with the topic and feel not prepared well enough to teach 'nano' at school, as 'nano' only plays a small part in the chemistry teacher training programs in Germany, if at all. The small extent of application of 'nano' in teacher education might result from high expenses which accompany the application of measuring instruments in this field, which are necessary to really explain phenomena. The learning tool atomic force microscope AFMone® provides an opportunity to use such an instrument in everyday teacher education, as it is comparatively cheap and enables real measurements. The AFMone® has a measuring range of 100 x 100 micrometers, shows structures up to 20 nanometers and therefore it allows an insight into micro- and nanotechnology. It is designed in a way that all components are free accessible, so that the function of the system and the data acquisition can be observed by learners as a realistic insight into the principle of atomic force microscopy. In contrast to other systems, the learning tool AFMone® allows the use own-produced samples. This allows an examination of macroscopic properties of nanomaterials and to combine this examination with the preparation of a sample and an analysis of its nanostructure. By this teacher students can experience macroscopic properties as results of nanoscale structure. The poster shows a selection of measurements carried out by chemistry teacher students which provide an insight into possible experiments which could be included in the regular chemistry teacher study course.

Analysis and Reflection of Different Learning Paths towards Electro Chemistry

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For many years an adequate handling of students' heterogeneity is demanded from (chemistry-) teachers. Even though schools often try to achieve homogeneity in their classes, the undertaken efforts seem to be insufficient, as especially the results of PISA have shown. Students are individuals and differ concerning their development and their achievements. Education can face this problem with the didactic principle of differentiation. Therefore, teachers are expected to reflect different possibilities of individual learning in (chemistry-) school lessons [1]. Thus, several approaches dealing with students' individual cognitive and conceptional ideas have been developed [2,3,4]. According to Tomlinson's proposition "a differentiated classroom provides different avenues acquiring content, to processing or making sense of ideas, and developing products so that each student can learn effectively" [5], the presentation will outline a project which aims at testing on how a design of different learning paths can be enabled to foster students learning and understanding of primary cells in electro chemistry. A differentiated instruction, students' self-assessment of this way of learning as well as the qualitative evaluation and reflection of students' learning process and -product will be presented.

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Development and Validation of a Basic Chemistry Concept Inventory Assessing Secondary School Students

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Educational research has highlighted the importance of students' prior knowledge in subsequent learning[1]. Thus, many chemistry concept inventories assessing students' chemistry understanding and measuring learning progression have been developed and proposed in the literature.[2],[3],[4] However, considering the great diversity of content and context of the chemistry curricula taught internationally, there is a need for broadening the inventories' base for chemistry educators and teachers. In such a perspective, the existing inventories should be used as a "starting point" for the development of an open item pool for a reliable and efficient assessment of secondary students' chemistry understanding.[4]

The present study describes the development of an inventory which was purposely designed to assess the extent to which students grasp basic chemistry concepts from a conceptual change perspective, as well as to detect the level of basic chemistry concepts misconceptions held by secondary students. The proposed Basic Chemistry Concept Inventory (BCCI) consists of 36 multiple-choice items, which cover "central" chemistry concepts and ideas in the secondary school chemistry curriculum (e.g. combustion, acids and bases). The content validity of the BCCI was tested by a group of science educators (in-service chemistry teachers and researchers). The group of experts evaluated the clarity of each item of the inventory. They also provided verification that the 36 items adequately examine certain basic concepts of the Chemistry curriculum at the Secondary level. The 36 items were pilot tested with 54 eleventh grade students, ranging in age from 16 to 17 years. The inventory test was administered to students in a paper and pencil form. During the completion of the inventory, students were asked to express their views about the consistency, the clarity, the difficulty, and the relevancy of each one of the 36 items of the inventory regarding their experiences and chemistry knowledge.

The data received from both the experts' evaluation and the pilot testing of the inventory indicated that the omission of six items out of the 36 was necessary. The revised version of the BCCI with 30 items has been recently administered to 271 eleventh grade students. The analysis of students' responses to the revised BCCI has indicated the adequate reliability and the validity of the inventory. To sum up, this study suggests that the use of the proposed inventory is a useful tool for teachers for organizing transformative instructional approaches and assisting conceptual change in their students.

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Chemie im kontext in spain: the adaptation of a context based methodology for chemistry teaching

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Chemie im Kontext (ChiK) is a project that aims to improve the chemistry teaching in 8th -13th grades (12 to 17 year old pupils) in the German education system. It provides the teachers with guidance, suggestions and collections of material, that they can use to build their own teaching units.

ChiK is a context-based methodology. The use of contexts allows the students to see the relevance and applicability of what they learn, so the new acquired concepts can be related to their previous knowledge, ideas and interests. One particular feature of this methodology is that it uses a student-centered approach. It focuses on promoting the students' self-concept and autonomy. The structure of the teaching units enables the pupils to use a variety of activities (research, lab work, discussions, team work) to achieve this. The implementation of ChiK in Germany showed promising results, especially in the field of students' motivation.

In order to find out which aspects different everyday experiences pupils have when using ChiK, our department of Chemical Education, at the University of Kassel in Germany, conducts a research project in Spain, where we have been working with some Spanish teachers for the last two years.

During the 2014-2015 school year, teachers from 4 schools in Madrid tested the ChiK methodology and some adapted material from the original German sources, for a 3-4 week period in their chemistry classes. In total, there were 10 classes (3th and 4th ESO in the Spanish school system) with 165 pupils involved. In order to measure the changes perceived when using this methodology, of both students and teachers, pre-test and post-test questionnaires, as well as personal interviews, were used.

These first results obtained in Spain are promising in terms of student motivation, self-directed learning and changes in the way they usually work during their chemistry lessons. The teachers' opinion on this methodology is also positive, and although there are some aspects that may hinder its use in a continuous way in Spain, they would use it for particular teaching units during the course.

In our poster we will show which results have we obtained in the first year of the project in Spain.

The greenhouse effect through experimentation activities to develop the argumentation capacity.

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Abstract: A greenhouse effect experiment designed with low cost materials was used in a high school classes to investigate how the phenomenon occurs in the atmosphere. Questions about the theme in a STS perspective were proposed to improve the students´ argumentation.

Keywords: STS, climate change, high school, greenhouse effect, experimentation.

The Greenhouse effect and its relation to climate change are constantly explored by the media, especially during the meetings between the world leaders. Unfortunately, the amount of content related to the topic does not mean clarity or precision about the information. It is not uncommon to find people who reproduce empty speeches about it without really understanding the phenomenon. Considering this problem, we developed teaching strategies to address questions relating to greenhouse effect inside a STS perspective, using experimentation and focusing on the importance of the development of argumentation. Working within the STS perspective is important because it gives a deeper comprehension of the world and that knowledge implies in an ability to act. It is the way in which knowledge generates individual and social capabilities which gives meaning to theorization (Fourez, 1995). In parallel to this, experimentation activities are more strongly used nowadays as a method of inquiry in Science classes than to just illustrate a phenomenon (Emden; Sumflet, 2016). Using an investigative approach, the students are able to observe and argue the reasons about a particular phenomenon (Vieira, 2012).

This study was conducted with public high school students in Rio de Janeiro with ages ranging between 15 and 18 years. A questionnaire based on the literature (Ikonomidis ***et al,*** 2012) was applied before starting the activities, in order to have a prior conception of the previous knowledge of students. A greenhouse effect experiment designed with low cost materials was used to show how the phenomenon occurs in the atmosphere. Simultaneously, videos and news were used to correlate the curriculum content with this phenomenon and its social, economic and environmental implications. The students were encouraged to discuss about how the greenhouse effect changes the climate on the globe and how this process affects mainly the poorest populations. According to Bakhtin, regardless of size, all expressions in the communication process are dialogical and dialogical relations can be conciliatory or not. Within a divided community in social groups with conflicting interests, the statements are spaces of struggle between social voices (Fiorin, 2011). Therefore, the development of this ability is necessary so that students do not absorb speeches without analyzing the relationships behind them. In this work, the investigative activities do not work as an exemplification of a phenomenon, but are the basis of tasks seeking individual growth of the students.

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Using different teaching aids to enhance conceptual development of students in a chemistry classroom

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One of the difficulties faced by teachers of natural sciences subjects in poorly resourced schools is related to the lack of teaching aids. Different studies indicate that poor performance of students in science is also linked to inappropriate conditions that vary from the lack of adequate infra-structures, laboratory equipment and chemicals [1, 2].

This paper reports the development and sharing of various teaching strategies and demonstrates their effectiveness in the teaching and learning of chemistry in Mozambique. The study is based on the constructivist learning theory to teach science and enhance the conceptual development of students [3]. The overall objective was to evaluate the potential of the combined use of educational posters and locally available materials for the improvement of educational results in the learning process of chemistry subjects in secondary schools.

Lessons observations, questionnaires, interviews and exam results analysis pointed out that many students encounter difficulties in topics related to chemical reactions. In this research we explored the use of easily accessible materials such as waste and plant extracts during the teaching process. We carried out a comparative study of the pedagogical outcomes of students in two classes, one taught using posters and locally available materials and the control group taught as usually, without specific teaching aids.

Overall, the results showed a successful application of the applied teaching methodology and can be used to encourage teachers to include low cost materials in chemistry teaching to enhance students' achievements and promote positive attitudes towards chemical science.

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Coal Power and acid rain: A COMBLAB activity to enhance chemistry competencies at secondary school

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This work is included as a dissemination task of teaching materials and results of classroom implementation of a COMBLAB activity. COMBLAB (2012-14) is a European Project. One of its objectives was to obtain research-based teaching materials using MBL real-time experiments for Secondary and High school Chemistry to enhance students' acquisition of science competencies through ICT real time experiments.

The activity "Coal Power and acid rain" has the validated general structure of COMBLAB activities: Engagement, Warming up, Experiment designing and conducting, Communicating results and Drawing final conclusions. The context of the activity is the acid rain problem and its relationship with combustion of fossil fuels. Students have to model phenomena and design experiments that help to find a possible origin of acidic rain. pH evolution was registered when samples of paper and sulfur were burned and the gases emitted were dissolved in water. Students relate the pH to the type of oxide obtained in the combustion.

In this communication the design of experiments, the experimental results, tips for teachers, the analysis of implementations and conclusions and implications were presented. Results were obtained by analysing questionnaires of a sample of more than 200 students (14 to 18 years old) from 5 secondary schools in Catalonia implemented during academic courses 2012-13 and 2013-14.

The analysis of questionnaires of student's perceptions show that 93% of students understood clearly what the activity asked them to do and were able to work in groups, but at the same time, a 70% of students said that they needed their teacher's help, especially in the design of experiments. Difficulties of students performing the activity have been also analysed and conclusions were drawn. Moreover some tips for teachers for future implementations are provided.

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Real-time experiments to enhance Chemistry Competencies in Secondary: The most efficient home-made fire extinguisher

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This work is a part of a European Project that has the objective to promote Science Competencies on students using real time experiments. In this communication the structure of a research based Microcomputer Based Laboratory activity for Secondary and High school Chemistry is explained. The activity, contextualized in fire extinguishers, works concepts related to speed of reaction in gases and promotes the design of experiments by students. It has been implemented at Secondary and High schools in Catalonia. Experimental designs and results obtained by students at school labs, and empirical data on student's perceptions of the difficulties to understand the activity and of the teacher's role have been analysed. Moreover some tips for teachers for future implementations are provided.

During two academic courses (2012-1014), the activity was implemented in four schools by 80 students in total aged from 15 to 18. Students were guided to work in an autonomous way. Their performance and motivation were studied using pre and post-tests. In the analysis of students' answers, we detect that a 90 % of them believe that they understand clearly the instructions given at the activity and its objectives. At the same time, 55% of students express that they had need the help of their teachers to achieve the objectives of the work.

As a conclusion we consider that the activity is suitable for students aged 15-18.

The role of the teacher is crucial, although nine out to ten students consider that the instructions of the activity are clear, half of them express that they need the help of their teachers.

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Butterfly effect in a chemical oscillator

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Abstract

The strong sensitivity on initial conditions is one of the fingerprinting features of chaotic systems, nevertheless it is quite difficult to be isolated in real experimental systems. In our work we discuss a didactic method to show the divergence between two infinitesimally different solutions of the famous B-Z oscillator undergoing a chaotic regime.

During the last decades, the paradigm of chaos theory has transversely flowered in scientific and non-scientific areas, including cinematography (eminent examples are Jurassic Park directed by S. Spilberg, Sliding Doors by P. Howitt and Chaos by T. Giglio) and digital arts (browse for instance http://musigen.unical.it). From a strictly scientific point of view, the concept of chaos identifies the onset of a long-term aperiodic behavior within deterministic systems. This kind of phenomena are commonly encountered in many practical problems ranging from medicine to meteorology.

The birth of chaos theory as a branch of science can be traced back to 1963, when in his seminal paper Edward Lorenz showed how a minimal model for describing the evolution of hydrodynamic flows in the atmosphere can exhibit a persisting aperiodic evolution, very sensitive to initial conditions. This feature, well-known with the popular expression ***butterfly effect***, represents one of the fundamental signature of chaos and implies the intrinsic impossibility to predict the long-term future of a chaotic system, despite its deterministic evolution.

The strong sensitivity of the dynamics on initial conditions is one of the fingerprinting features of chaotic systems. While this dependence can be directly verified by means of numerical approaches, it is quite elusive and difficult to be isolated in real experimental systems.

We present a didactic experiment to follow growing differences between two identical replicas of an oscillatory chemical reaction undergoing a chaotic transient in closed and unstirred reactors to give a didactic view of the butterfly effect, not easy to be caught in real systems.

To this end we consider the famous Belousov-Zhabotinsky (BZ) reaction which, after many years from its discovery, is still regarded as the prototype for studying nonlinear phenomena in chemical systems. This reaction exhibits a transition from periodic to chaotic oscillations due to the interplay between chemical kinetics and transport phenomena, in particular hydrodynamic motions.

Experimental data are also used to give an intuitive visualization of the Lyapunov exponent, which allows for a more quantitative characterization of the chaotic dynamics.

Our approach is suitable for two purposes: (i) a direct visualization of the sensitive dependence of chaotic transient on initial condition and (ii) an intuitive description of the exponential divergence (positive Lyapunov exponents) which intimately characterizes chaotic trajectories. The method presented here features a practical support for introducing nonlinear kinetics and chaos theory for undergraduate students in scientific areas.

Design teaching sequences with augmented reality to promote visualization in chemistry.

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Visualization is one of the most important skills for science learning because there are complex concepts that refer to entities (e.g., atoms), properties (e.g. energy) and processes (e.g., metabolic pathways) at microscopic levels that can not be displayed or naked eye represented. (Gilbert, 2005). Visual models are used, as e.g. diagrams and animations to represent these events on a larger scale, to help students build knowledge of the contents. (Gilbert & Treagust, 2009). While there is plenty of theories about it (Gilbert, 2005), it is necessary to provide more examples of educational materials in the classroom on the nature of visualization for science education (Phillips, Norris, & Macnab, 2010). Also, there remains a gap in the literature regarding the nature of the representations based on the cognitive process of visualization, and even more about teaching sequences (TS) aimed towards promoting visualization for high school student . Our goal is to design, implement and evaluate TS in high school, by the implementation and validation of learning materials on main topics of chemistry and promoting metavisual ability by increasing visualizations (Gilbert & Afonso, 2014) with augmented reality (Carmigniani & Furht, 2011). The research design is framed from the perspective of Educational Design Research (Plomp, 2009) and take into consideration 3 phases (diagnosis, design and evaluation). Phase 1: for selecting the topics of the TS a survey of more than 5100 schools across the country was sent in digital format. Chemistry teachers were requested to select the issues that are complex to teach and have a high potential if materials were designed with a narrative that is significantly enhanced by augmented reality visualizations (Gilbert & Afonso, 2014). From 284 responses collected, the mostly topics selected by teachers were: a) quantum theory, b) spatial distribution of molecules, c) intermolecular forces, d) stoichiometry, e) colligative properties, f) physico-chemical properties of carbon and g) three-dimensional structure of organic molecules. Later, school and college textbooks were revised about the presentation of these issues from factually, resources and use of images perspective, finding that almost all the illustrations are "descriptions" that deliver data or exemplify the statement by the main text; plus some trivial explanations were evidenced. The presence of any "prediction" or "action" was not found. We are currently in the design phase and adjusting the TS according to inputs from the diagnosis stage, and examples will be shown at ECRICE2016.

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Supporting In-Service Chemistry Teachers to Pedagogical Effectively Integrate Virtual Laboratory in their Teaching through a Blended Professional Development Program in Greece

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The integration of Information and Communication Technologies (ICT) into classroom continues to be a challenging task for many Chemistry teachers. The main reason is to proceed in pedagogically and technologically effective integration of technologies in their teaching. The essential qualities of knowledge and skills required by teachers for effective integration of ICT in their teaching are described as Technological Pedagogical Content Knowledge (TPACK) (Mishra & Koehler, 2006).

In Greece, a blended, Teacher, Professional, Development (TPD) Program supported by the Ministry of Education and Institute "Diophantus" was designed, developed and implemented to in-service Science teachers. This program concerns Science teachers, among them Chemistry teachers and help them for the development of their TPACK. Especially, the Blended TPD program combining live sessions, synchronous sessions from a distance through BlackBoard Collaborate (BbC) and asynchronous activities through Moodle.

This paper presents information on the structure and content of sessions of the blended TPD program, regarding the use of virtual laboratories such as the IrYdium Virtual Chemistry Laboratory (IrYdium VLab) in teaching at Secondary level of Education. During these sessions Science teachers have the opportunity to understand the advantages, that virtual laboratories as well as spreadsheet software offer and also how to use them for supporting teaching and learning. Furthermore, teachers learn to design educational activities, worksheets and instructional scenarios, which are based on the use of IrYdium VLab as well as Excel and followed the approach "Prediction–Experimental Control–Explanation – Conclusions".

Investigating the effectiveness of the TPD program on the development of teachers' TPACK, many data sources were used (e.g. the recordings from synchronous remote discussions in BbC, the relevant posted comments at the forum in Moodle platform and the teachers' responses to questions regarding Virtual Labs in the survey questionnaire after the completion of TPD program). The result analysis of this study was based on aspects of Science teachers TPACK development.

In conclusion, the findings of this study reveals that the combination of synchronous and asynchronous sessions regarding the pedagogical use of IrYdium VLab helped teachers:

to recognize the utilities and appreciate the benefits of Virtual Chemistry Laboratories such as IrYdium VLab (Technological Knowledge enhancement), to experience ways of pedagogical integration of IrYdium VLab and Excel such as in educational Chemistry worksheets (Technological Pedagogical Knowledge improvement and Technological Pedagogical Content Knowledge development) and to understand aspects of their teaching of specific Chemistry modules in their classroom (Technological Pedagogical Content Knowledge development).

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An Activity for Teaching Heat Concept to Visually Impaired Students

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Visual impairment is a decreased ability to see to a degree that causes problems not fixable by usual means. Concepts in science and mathematics have been found inaccessible to students with visual impairment due to use of figures, equations and graphs. Teachers can make the world of science more accessible to students with visual impairments through collaboration and specific adaptations in both the science classroom and laboratory by providing students with a variety of opportunities to explore and examine real materials closely or use models.

This study aimed to develop an activity, as part of a large project, which is accessible to visually impaired students in teaching heat concept which is found difficult to comprehend even by the sighted students. For this purpose we have designed an activity based on using tactile materials for making science more accessible to 8th grade students in a special school for visually impaired. Participant of this activity was six students including a blind student. The activity is basically consists of simple, economical and easily accessible everyday materials. Two plastic bottles, one of which includes warm water and the other includes cold water was given to every students to hold them with their each hands. Then students were questioned through inquiry based questions during the following 20 minutes. Before the activity, participants were interviewed to see their conceptual understanding of heat. There were typical misconceptions among the students about heat. In the follow up interviews four weeks after the activity took place nearly all of the students were able to answer questions about "heat" concept and did not displayed the misconceptions.

Mathematical Modelling in Chemistry Lessons – Theory and Reality

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Considering the acquisition of problem solving skills in chemistry, tasks aiming at problem solving by using mathematical models like equations, functions, graphs or geometric figures seem to be beneficial: A conscious handling of mathematical models describing chemical facts or data demands a deeper comprehension of the modelled terms and leads to a transfer of mathematical knowledge in significant situations. Such a conscious way of using mathematical models in chemistry lessons is enabled by the so-called mathematical modelling, which means that mathematical models are created by the learners themselves and used in a process of explaining chemical facts and data in order to solve a chemical problem or to answer a chemical question. In order to learn more about this process, we developed a model, which describes the process of mathematical modelling in chemistry in detail and which helps explaining teaching-, learning- and thinking-processes (Goldhausen & Di Fuccia 2014).

Up to now, there is rare reliable information available from research on the question of how to teach mathematical modelling in chemistry lessons. Respectively, it seems to be unknown to what extent and in which way practicing might foster students' competences in mathematical modelling in chemistry. Based on results from mathematics education (Blum & Borromeo Ferri, 2009) and from our video-study on on the students' difficulties with mathematical modelling in chemistry (Goldhausen & Di Fuccia 2014), we are going to evaluate the effect of involving students in modelling processes by using tasks, which ask for both chemical and mathematical modelling. At the moment, we develop respective tasks and check whether the results of our video study are transferable on those examples by means of a second video study. The poster shows the developed model of the process of mathematical modelling and furthermore selected examples of modelling tasks and related stepwise learning aids.

Designing a curriculum that gives students a relevant, meaningful interesting and worthwhile experience of chemistry

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Abstract

This paper presents the experience of participants involved in the design of a new chemistry curriculum aimed at providing students with a motivating and relevant experience of chemistry that equips them with understanding and skills. Stakeholders' views about the new curriculum, challenges envisaged and support needed are presented.

Many European countries have for years experienced a worrying decline in students' interest in science (Rocard et al., 2007). This decline has often been attributed to the way science is taught in schools. Malta is no exception – with chemistry suffering a severe decline in popularity at Secondary level (age 14-16). The number of students sitting for the end of secondary education examination in chemistry has dropped by 15% between 2004 and 2015. The existing science curricula in Malta, and the chemistry programme in particular, are full of scientific knowledge and much of the teaching is limited to transmission of knowledge with little "time for experimentation and reflection, depriving students from understanding the process and nature of science" (MEEF, 2011, p.20). High stakes examinations at the end of compulsory education tend to encourage teaching to the test in traditional classrooms through teacher-centred instruction. This appears to be common practice in chemistry teaching in Europe where the use of teacher-centred methods such as working out exercises appear to be particularly frequent unlike the use of investigations (Maaß and Euler, 2011).

In addition, the current curriculum still presents chemistry as a rather fragmented body of knowledge that is abstract, encourages memorization and is irrelevant to students' everyday lives. For years, educators have felt the need to move towards a curriculum that is relevant to students and through which "knowledge, skills and values are developed" (Pace, 2000 p.2).

In 2012 the new National Curriculum Framework was published which lead to the development of the Learning Outcome Framework for the different subjects studied at compulsory school age.

This paper will look at the experience of the participants involved in the design of a new curriculum, organized around themes that aims to help students develop scientific understanding; scientific inquiry skills; and ability to relate science to technology, society and the environment. Their thoughts, feelings, views and challenges encountered will be presented together with feedback from various stakeholders. Teachers who will be key players in the proposed change also provided information about challenges envisaged when enacting the program as well as the type of support they required.

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What happens with students at gymnasium level – is there any change of the levels of scientific literacy?

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Abstracts

The purpose of this study was to investigate the change of student`s scientific literacy levels throughout the gymnasium studies. Students` cognition associated with scientific processes, understanding the nature of science, construction of concept maps and comparing students' achievement with their self-perceptions against the same skills were tested by complex instrument.

For this study scientific literacy is taken to mean to utilize science knowledge and skills for everyday life and a career, in solving personally challenging yet meaningful scientific problems as well as making responsible decisions (Holbrook & Rannikmäe, 2009). The current study focused on aspects in which 15 year old students did poorly, based on PISA results. Assessment of scientific literacy skills based on real life situations motivates students to answer (Bennet et al., 2007; Roberts, 2007). The instrument was designed around 4 real life interdisciplinary situations challenging students to utilize knowledge and skills for problem solving and decision making and constructing concept maps related to those. Both, content and context validity were checked. A representative sample was composed, involving over 1800 students from 44 schools. Students were tested in grade 10 and 12.

The results showed that over the gymnasium studies there was no significant changes in students' problem solving, reasoning and decision making skills. These skills remained on low level. Significant changes appeared in content acquisition, this was subject specific – more in biology and geography, much less in chemistry and physics related content. Similar patterns were illustrated by concept maps characteristics. Results show that students agree that science subjects develop the competence to recognise the importance of science in society and to reason. However, students disagree that science subjects, in general, focus on aspects of problem solving like posing scientific questions or planning scientific investigation. There is a need to overcome the gap between the skills promoted in the different disciplines so that the education offered is seen as promoting the range of education goals, linked to the development of levels of scientific literacy. The change of the levels of students` scientific literacy during the gymnasium years can be described by four dimensional hierarchical model. More detailed research outcomes about students' actual results will be discussed in the conference with the major emphasis on students` achievement in chemistry related learning.

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Particles: what are they? A proposal on a learning progression about the particle model of matter for upper secondary school

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Abstract

This proposal presents an empirical learning progression and a designed teaching sequence addressed to 10th graders on the particle model of matter with the purpose to integrate different explanatory models of physical and chemical phenomena, which are usually isolated and disconnected in school science curriculum and textbooks.

Previous research studies evidence that some of the obstacles to the evolution of secondary school students' conceptions of dissolution might be related to their difficulties understanding the particle model of matter (Hadenfeldt & Neumann, 2014). Although there is a great number of studies on learning progressions about matter throughout different educational grades (Liu & Lesniak, 2006; Smith & col., 2006; Johhson & Tymms, 2011), there are not so many about how (i.e. teaching strategies) to make secondary school students progress towards the particle (conceptual) model of matter.

The official secondary school science curriculum in our context regarding this topic includes the analysis of certain physical and chemical phenomena (e.g. diffusion, dilatation, state change, radioactivity, chemical reactions) in terms of the kinetic theory, the atomic theory, and the chemical bonding model. However, there is a lack of explicit connection between those phenomena and models, and between these different theories and models. Although experts are able to establish connections with appropriate theories / models for each phenomenon, it seems, in the light of previous research studies, that most students are not able to do the same. One possible reason is the lack of explicit links throughout secondary education between different phenomena and different explanatory models.

The main teaching goal with regards to this topic is to develop secondary school students' competence to explain phenomena related to matter in submicroscopic terms. Nevertheless, to be able to do so, students need to deeply understand the particle model of matter (including all the aforementioned theories and models), going beyond a basic level of understanding, which just takes particles (atoms and molecules) into consideration but without distinguishing them and without considering other particles such as ions.

Our proposal is aimed to design an empirical learning progression, which relates macroscopic phenomena, the nature of particles (atoms, molecules and ions) and the interactions among them (interatomic and intermolecular), in order to promote the evolution of secondary school students' mental models towards the particle model of matter. In order to empirically validate (Duschl, et al. 2011) this learning progression, we have designed a teaching sequence, addressed to 10th graders (last year of compulsory secondary school in our context), which will be implemented, analysed and refined in later academic years, according to the design-based research (DBR) paradigm.

Both the learning progression and the designed teaching sequence will be further discussed in the conference.

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Students' self-perceptions about big ideas in science education

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Throughout the world, science education has faced a number of inter-related problems, such as overloaded by content, containing isolated facts, lack of transfer, lack of relevance and inadequate emphases (Gilbert, 2006). Part of the solution to these problems is to conceive the goals of science education, not in terms of an isolated body of knowledge, but as a progression towards big ideas, which together enable understanding of events and phenomena of relevance to students' lives during and beyond their school years (Harlen, 2010). Determining that valued in science learning helps to organize important and less important knowledge omitting isolated facts not seen as helpful in deepening the ability to explain the world around us scientifically (ibid). The NGSS (Next Generation Science Standards) framework identifies seven ideas, or crosscutting concepts (patterns, similarity, and diversity; Cause and effect; Scale, proportion and quantity; Systems and system models; Energy and matter; Structure and function; Stability and change), which are designed to be taught in the context of different science disciplines – not in a vacuum (NRC, 2012). In this work the crosscutting concepts in different contexts are termed big ideas. The science curriculum activities need to deepen understanding of the scientific big ideas in addition to other aims, such as fostering attitudes and capabilities (Harlen, 2010). At the end of schooling, these big ideas should help to explain natural phenomena, help solve everyday life problems and help students to make decisions regarding socioscientific issues (NRC, 2012).

The goal of this study was to construct crosscutting concepts into a context for each different science discipline within the curriculum, as well as determining 12th grade students self-perception in understanding big ideas in different science disciplines. The study additionally seeks to find out students' opinion about the importance of big ideas for students to be more successful in every-day life. With this in mind, several big ideas were constructed, derived from responses to a questionnaire.

Results showed that students' self-perceptions were higher for wider understanding than in specific every-day contexts and they feel themselves more confident in knowledge of geography and biology but less so in chemistry and physics. For example, students can explain the energy conservation law, but they can´t explain the principle of an electric generator. The results showed that, in chemistry subjects, students evaluated the importance of understanding concrete life-related knowledge for their future life statistically higher than their actual ability about an understanding of such knowledge. For example, in their opinion, students needed more knowledge about redox reactions than they have gained it until the end of 12th grade. This suggested that students still valued and thus sought to connect crosscutting contexts with everyday- life aspects more than their teachers are doing, especially in lessons of chemistry and physics.

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Visualisation of hydrogen bond in water dimer: Representations by Finnish teacher students and in-field teachers

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Chemical bonding is one of the key concepts in chemistry. Learning chemistry requires understanding of the physical forces behind chemical bonds, understanding how the consequences of interactions on the microscopic level appear on the macroscopic level, and how the chemical bonds are presented.

The hydrogen bond is a special case of weak intermolecular interaction, where the interaction is mediated by a positively charged hydrogen atom between electronegative moieties (Arunan et al., 2011). The hydrogen bonds in water result in numerous physico-chemical anomalies, important biological properties (Marechál, 2007) and a constant use of such interaction as a learning target in chemistry education (Ünal, 2006).

This research focuses on chemistry teacher students' and in-field teachers' representations on the most simple hydrogen-bonded model of water, i.e. the water dimer. Here, we investigate how the water dimer in understood, visualized and especially how the hydrogen bond and the molecular structure are pictured. The study analyses drawings collected in various in-field teacher training courses and chemistry education courses (Pyykkö, 2014; Rajamäki, 2015).

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Phenomenological primitives (p-prims) in chemistry

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Phenomenological primitives (p-prims) are simple abstractions of a personal common everyday experiences, and support the development of ideas that are intuitively accepted. P-prims mainly were used for explaining students' misconceptions in physics, but are not widely studied as cognitive resources of misunderstanding in chemistry.

The aim of our study were exploring, collecting, and classifying the p-prims-based misunderstandings in chemistry. The sample involved 429 students (aged 14-19; grade 9-13) from a chemistry vocational school. We used a written test with 17 typically misunderstood chemistry problems.

We explored the following p-primes among students' answers:

- More is stronger – 'The pyrimidine is stronger base than pyridine, because pyrimidine contains two nitrogen atoms.'
- More is bigger – 'The higher atomic number means more particles in the atom, and higher atomic radius.'
- More is higher – 'The higher in molar mass is the higher in boiling point.'
- More is more effective – 'The higher amount of flammable petrol is more explosive'
- Equilibrium is equality – 'In the equilibrium the concentrations are the same.'
- Natural is healthier – 'The natural vitamin C is healthier than synthetic one.'

In a few cases we found p-prims and misconceptions parallel:

- P-prim: 'Sodium has higher density than water, because sodium is solid/metal.' Misconception: 'The molar mass of sodium is higher, than molar mass of water; therefore sodium has higher density than water.'

More examples and the discussion of the results will be shown as a poster presentation.

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Results of the project "Yum yum…good this Science!" How to deal with Food Chemistry and Education at the Primary School.

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During the academic year 2014-2015, a project about "Food Chemistry and Education" called "*Gnam gnam… che buona la scienza!*" was proposed to about 150 children attending the forth and fifth classes of the Primary school (i.e. 9-11 years old).

The project included seven main topics (nutritional aspects, chemistry of food, food education, testing food with senses, safety issues, digestive system, food pyramid) and it was developed by using cooperative learning, problem solving method, inquiry-based learning, interactive demonstrations and laboratory-centered approaches [1-3].

The teachers could choose some of the proposed activities and topics; a group of twenty students of the fifth class tested the whole project devoting to it the whole year. The main results of the project in terms of reached skills and competences will be discussed [4].

Figure 1. Representative photos of the various steps of the project.

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Inspiring Early Elementary School Students (Grade 1, 2 and 3) with Chemistry. STEM Program at Anatolia College in Greece

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When we talk about "Science Technology Engineering and Mathematics (STEM) Education" we refer to Education, which includes new innovative approaches to Teaching and Learning of Science, Technology, Engineering and Mathematics at all Levels of Education, from Primary to Higher Education in all its forms, Formal and Informal Lifelong Education. STEM is an interdisciplinary and applied approach, which is based on learning through scientific research and its applications in the real world.

Children from an early age exhibit curiosity about the world around them. In an effort to explore the world, children develop some research skills. Nonetheless these skills, resulting from trial and error activities, are limited in number and insufficient for the systematic study of the natural world.

STEM program for elementary students (Grade 1, 2 and 3) at Elementary School of Anatolia, is aimed initially to help students to get involved on simple scientific practices such as "observation", "comparison", "classification" and "posing questions". The main idea of the first part of the program is reflected in the following phrase: "What do Scientists do? The Scientists observe. The Scientists measure". For this purpose, teaching scenarios and worksheets, which cover basic concepts such as length, width, weight, mass, volume of liquids, the capacity of container, the states of matter and help students exercise to measure e.g. length, width, mass and volume of liquids have been designed and developed.

These skills consist the basis for students to develop more complex skills and abilities during the STEM program, such as "making a prediction", "conducting an experiment", "making observations" and "making, documenting, analyzing and interpreting experimental measurements and data", "drawing conclusions", "assessing" and "discussing" the experimental process with their fellow students, in order to approach the world in a more systematic, methodical and meaningful way.

The second part of STEM program, we have purposely designed and developed exploratory teaching scenarios and worksheets, which are based on simple experimental activities, which are appropriate and suitable for grade 1, 2 and 3 elementary students, such as gas production from carbonate reaction with acid (baking soda with vinegar, lemon juice with chalk), examination of heat influence on the solubility of the salts (e.g. sodium chloride / salt) in water, separation of mixtures (e.g. liquid–liquid mixture, liquid–solid mixture). Furthermore, in this second part, purposely designed experimental laboratory activities as well as thoroughly selected experiments which are provided from international literature and could be characterized as "Kitchen Chemistry Experiments" are also included. The proposed "Kitchen Chemistry" experimental activities required exclusively common, harmless, non-toxic and inexpensive materials, which are found in the kitchen of any household.

STEM program is designed to encourage students to love science and conceptualize that they can adopt and apply research practices in order to answer questions or solve problems related to their daily lives. The involvement of early elementary students in simple scientific activities and processes prepare them for their future participation in STEM activities within the school and outside school. Finally, STEM program at elementary level increase students' interest in Science and Technology disciplines, which will have the opportunity to see through useful applications in their everyday life and not as an additional compulsory subject in the school curriculum.

Science Education in Out-of-school Contexts – Comparison of Users' and Providers' Ambitions and Perceptions

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Out-of-school settings for learning are currently a topic of discussion (Rennie 2007; Reiss 2012). There is a wish for opening schools to new learning experiences that promote student learning. In particular, school laboratories for natural sciences organized by institutions or companies other than schools seem to be especially promising regarding the promotion of young researchers, as they provide opportunities for students to conduct experiments in the context of current scientific issues and to do so in an authentic environment.

Impact studies on the efficiency of school laboratories for natural sciences suggest that making use of school laboratories has positive short-term and middle-term effects on students' interest as well as on their ability to assess their learning process. These results indicate that integrating out-of-school places of learning at least helps to stabilize students' interest. But students who visited school laboratories and conducted experiments there did not learn as efficiently as students who worked on the same topic in class as far as chemical content knowledge is concerned (Guderian&Priemer 2008).

To understand which characteristics of school laboratories contribute to these different effects, we carried out a questionnaire study (N=187) and an interview study (N=30) with German teachers and principals asking for their perceptions of the impact of science education in out-of-school contexts, their expectations of this type of learning and their corresponding personal experiences. Furthermore, we carried out a questionnaire study in which we asked German providers (N=114) of school laboratories for natural sciences organized by institutions or companies other than schools about their ambitions and the respective realization.

The poster shows selected results of these studies and points out a comparison of users' and providers' ambitions and perceptions. The results may lead to changed school laboratory settings that might lead to a better learning efficiency.

Engaging future teachers to promote RRI: Implementing *Engage Project* digital materials related to chemistry big ideas

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Lately, in many European Union countries, teaching of experimental sciences has been inspired by a trend observed in public policies called RRI (Research and Responsible Innovation), that involve citizen participation in research and scientific innovation.

In parallel, teaching science is affected by the overall shift to competency-based education. This sets the need to design learning activities which enable pupils to express their views on a single scientific fact based on scientific knowledge, as well as to understand the implications of scientific and technological developments in their life. The ENGAGE project addresses this need by providing teachers with examples of activities that promote changes in how science is taught, thus equipping students to participate in scientific issues.

Initial teacher training should respond to these changes and incorporate these kinds of teaching materials in primary and secondary school teacher training. We have included this new approach to scientific competency into the teacher training for primary and secondary teachers' lesson plans, as a preliminary experience. Results are presented in this communication.

The ENGAGE activity adapted as a pre-service teacher training material is the "Big bag ban". In this activity students decide whether to replace ordinary polythene plastic bags with degradable bags (biodegradable or oxodegradable bags). The chemistry big idea related with the activity is the model of matter and chemistry reaction. In the field of Science in society, pupils evaluate the merits of a solution to a real-world problem.

This communication explains and evaluates the implementation of this activity among students of a subject of 2nd level of Primary Education Degree (around 70 students) of the University of Barcelona, and Post-graduate students (around 20 students) of Master of Teacher Training of Science at Secondary School. In both cases the written productions of students (future primary and future secondary teachers) and their performance using a Jigsaw II methodology were analyzed.

The analysis of argumentation text shows the key ideas of chemistry underpinning students' decisions. Results show that some future teachers need to increase their skills to develop arguments in general and structuring and scaffolding is needed, while others have these skills but are not able to use or construct key science-based chemistry ideas in these type of activities. The level of explanations is consistent with the level of students. Future primary teachers use the idea of types of material related to their capability to transform, while future teachers at secondary school deepen in the idea of polymeric material, chemical reactions and catalysis, and the difference between process in presence or absence of air and light. The results of those practices and the reflection about students as future teachers provide clues and ideas on how to help them to transfer and /or adapt these activities with their future pupils.

Future Learning. http://www.ub.edu/euelearning/

Engage Project. https://www.engagingscience.eu/es

Playing with the sense of smelL. A Workshop to improve organic chemistry and Food Science education

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Keywords: Experiments in Organic Chemistry teaching, Chemical & Food Science education, Teacher training, sensorial analysis.

For many years in our university, natural products have been a useful tool in chemical education subjects in various degrees, such as: Teacher Training Degree, Agricultural Engineering, Food Science and Technology, Human Nutrition and Dietetics [1-3]. As a part of this process, experiments had been carried out and, finally, in 2000, a workshop was offered in the Catalan Official Science Week, promoted by "Fundació Catalana per a la Recerca i la Innovació" (FCRI).The structure of the present workshop summarises our contribution to the Norwegian Science Week in 2006, as an invited activity by the FCRI (as a member of the WONDERS Project– "Welcome to Observations, News & Demonstrations of European Research and Science"). The activity was organized at two levels: for the general public and non-Chemistry students (Level 1) and for Chemistry students from Secondary to University education (Level 2).

The general aim of the workshop was to introduce education on the sense of smell and to practise how our sense of smell works to identify odours by using common products (Mediterranean aromatic plants and spices). Specific objectives were established for secondary and tertiary Chemistry students: a) to review various Organic Chemistry concepts related to natural products, such as structure, activity and properties of their volatile compounds (VC); b) to practise experimental extraction techniques for essential oils; c) to show the most important techniques applied in odour identification (olfactory analysis, gas chromatography/mass spectrometry and electronic nose).

Interactive and experimental tasks to discover and identify odours from the exhibited products were performed, based on a Power Point presentation and on sensorial test experimentation, according to the level of the attendees. Various aromatic plants (fresh-10, dried-8), spices (8) and extracts (in different supports: fat-3, oil-4, water-4) were tested. Finally, a set of individual samples of the twelve most significant odours in wine testing and twelve samples of the industrial concentrate extracts of aromatic plants and cooked meals were tasted. Details of sensorial analysis and results will be given. The duration of the workshop was from 2 to 4 hours depending on the level (1 or 2). Extra time would be possible, if the teacher of each group wanted to know more about this topic.

Theoretical information was given at the molecular level of the sense of smell, including odour class, olfactory receptors, VC in natural products, specific functional group in VC molecules and the shape of the molecule related to odour quality and intensity. Experimental and complementary activities were proposed: sensorial analysis qualifying olfactory sensations and the analysis of the collected data, extraction of the VC from natural products through a steam distillation in the laboratory and introductory research on identifying VC with instrumental techniques. A table with contents, activities and acquired competences by the attendees will be given, in order to summarize this proposal.

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Authentic/ alternative assessment, v: classification of organic compounds, reactions/mechanisms by Science Majors

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The purpose of this study was to investigate the ability to complete, identify and classify common organic reactions, the mechanisms by which they take place and the major organic reactants/products.

A pilot study was made with majors/non-majors to observe their classification skills with a sample of 50 reactions which were taken from well known organic chemistry texts like Mc Murry Organic Chemistry.

The instrument was administrated to about 60 chemistry majors and non-majors (Biology) who had approved from 16 to 40 chemistry semester hours. The results demonstrated that 98.0% of the subjects had forgotten almost 100% of the type of classes (e.g. compounds, reactions, mechanisms involved in the reactions). Only about 2% remembered very few concepts.

The study was repeated for several semesters with the purpose of reproductibility. The results were very similar. There was no significant statistical difference between the mean scores of majors and non-majors.

These findings have been observed in several classification studies (e.g. compounds, reactions, equations, problems) of the author and others. The implications for chemical education, science and mathematics in general are relevant since these findings reflected rote-memorization not genuine understanding, permanent learning, nor long term memory (LTM).

Keywords: Research in science education, constructivist methodology.

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Authentic/ alternative assessment, v: performance of science majors/non-majors on the categorizing grid

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The purpose of this study was to investigate the categorization capacity of college students in a categorizing grid of general chemistry compounds and to compare their classification ability with other categorization schemes like conceptual maps and tables. These studies have been done for several semesters with about 50-60 subjects for reproducibility. Almost all students have showed very little knowledge of the classes of compounds and taxonomic rules. There was not significant statistical difference between the mean scores of majors/non-majors. Since classification is pervasive in nature and science this study is relevant in science education.

Keywords: Research in chemical education, classification, science education

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Authentic/ alternative assessment in chemistry/ science education v: the effect of the auto quiz on the achievement of science college students

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The autoquiz is an assessment technique in which the students read, understand, analyze, synthesize and evaluate the assigned topics (e.g. chapter). Then they prepared 15 questions of the most relevant content of the chapter. After they have learned the answers (and reasons for the best or most correct of them) they presented the autoquiz orally to the class. The professor evaluated both the quality of the questions, answers, reasons and examples provided by each student according to the written instructions.

The sample had consisted of about 50 students per semester during several semesters. The students, who prepared, presented and approved one autoquiz per chapter also approved the regular quiz and three exams of the professor with 80% to 100%.

In addition, the autoquiz students also approved the course with 90 to 100%. This constructivist technique was invented and applied by the author and has been very effective in demonstrating the extent of understanding of a topic. There was a significant statistical difference between the mean scores of regular and autoquiz students. This study is relevant for chemical, science education and science in general since this constructivist technique promote the development of higher cognitive skills, it' is relevant for science and science education.

Keywords: Research in science education, constructivist methodology

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Camacho, M. and Good, R. (1987) Problem solving and chemical equilibrium: successful versus unsuccessful performance, *Journal of Research in Science Teaching*, Vol. 3, pp.251-272.

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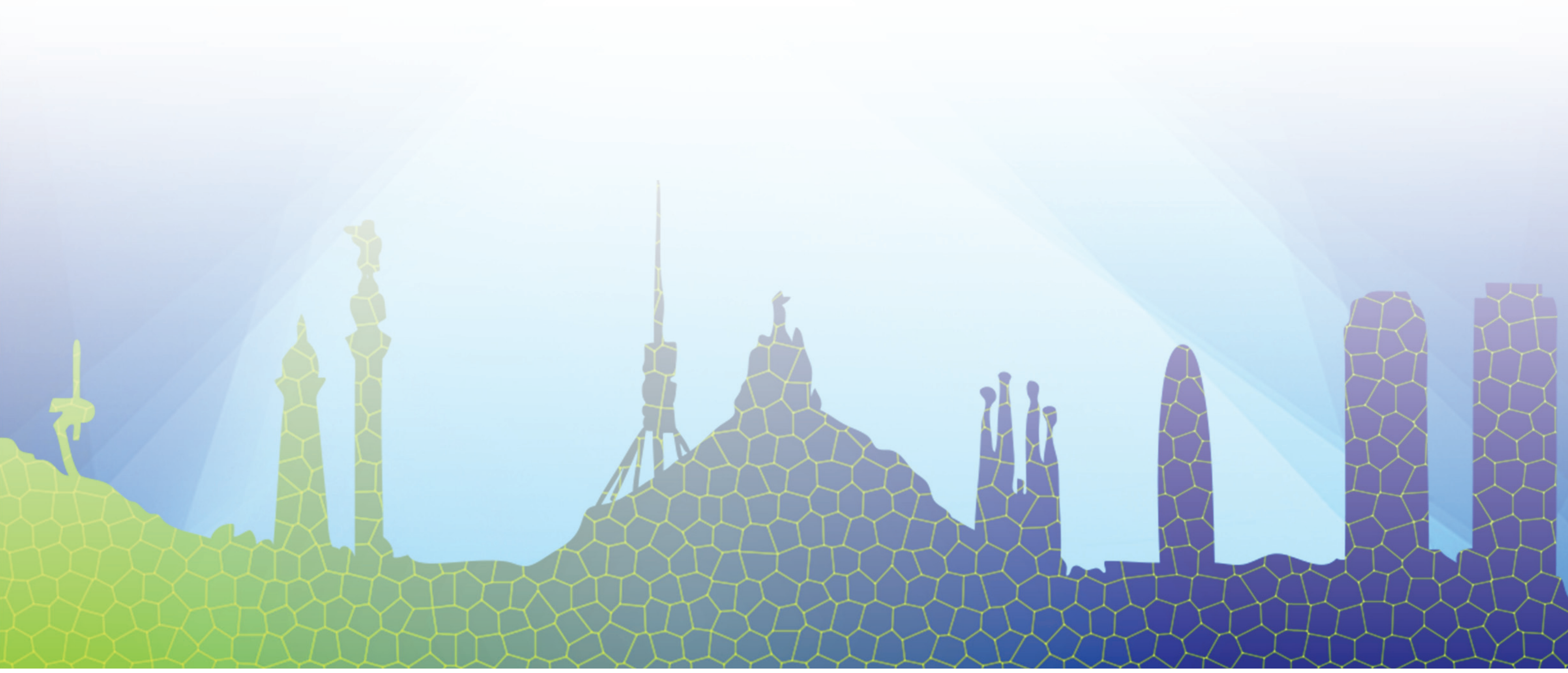

Workshop

Quality Publishing in Chemistry Education journals

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Although we are living in times of the Internet and social media, publications in scientific journals are still the main form of presenting and discussing academic achievements in the sciences. Journals are even suggested to define any corresponding academic discipline: *„the presence of the journals is an acknowledgement of the existence of a field, and the journals act as gate-keepers to determine what is considered work that both falls within the scope of the field and reaches the standards expected in the field"* (Taber, 2012). Concerning the individual researcher, the commonly used phrase *„publish or perish"* describes that academic careers in most scientific disciplines are still built up mainly on publication output, although many related practices are also under critique (Roth, 2005). While publication practices in chemistry are well sorted and most relevant journals are listed in the Web of Knowledge, this is not the case in science eduction in general and chemistry education in particular. The world of chemistry education encompasses more forms of publications rather than scienctific journals. It covers a range from academic to teacher journals, book chapters are more recognized in the field of education than in the sciences, and to support teachers science educators are also quite frequently involved in school textbook writing and classroom materials development. The more, if it comes to adressing teachers, many relevant stuff needs also to be published in the different national or local languages (Eilks, 2009). However, for academic careers in chemistry education in many countries quality publications in peer-reviewed, international journals are required. Fortunately, the number of international journals in science education listed in the Web of Science started growing significantly in recent years (Schönborn, 2014). Among these journals there are two major international journals only adressing chemistry education: The *Journal of Chemical Education* published by the *American Chemical Society* and *Chemistry Education Research and Practice* issued by the *Royal Society of Chemistry*.

This workshop is addressed to young researchers in the field of chemistry education. The organizers will provide an overview on the different characters of the *Journal of Chemical Education* and *Chemistry Education Research and Practice.* They will provide an overview about recent developments in both journals. This will be followed by an open forum for the participants to ask questions on any issues related to publishing in the two journals in particular or in chemistry educatoin in general.

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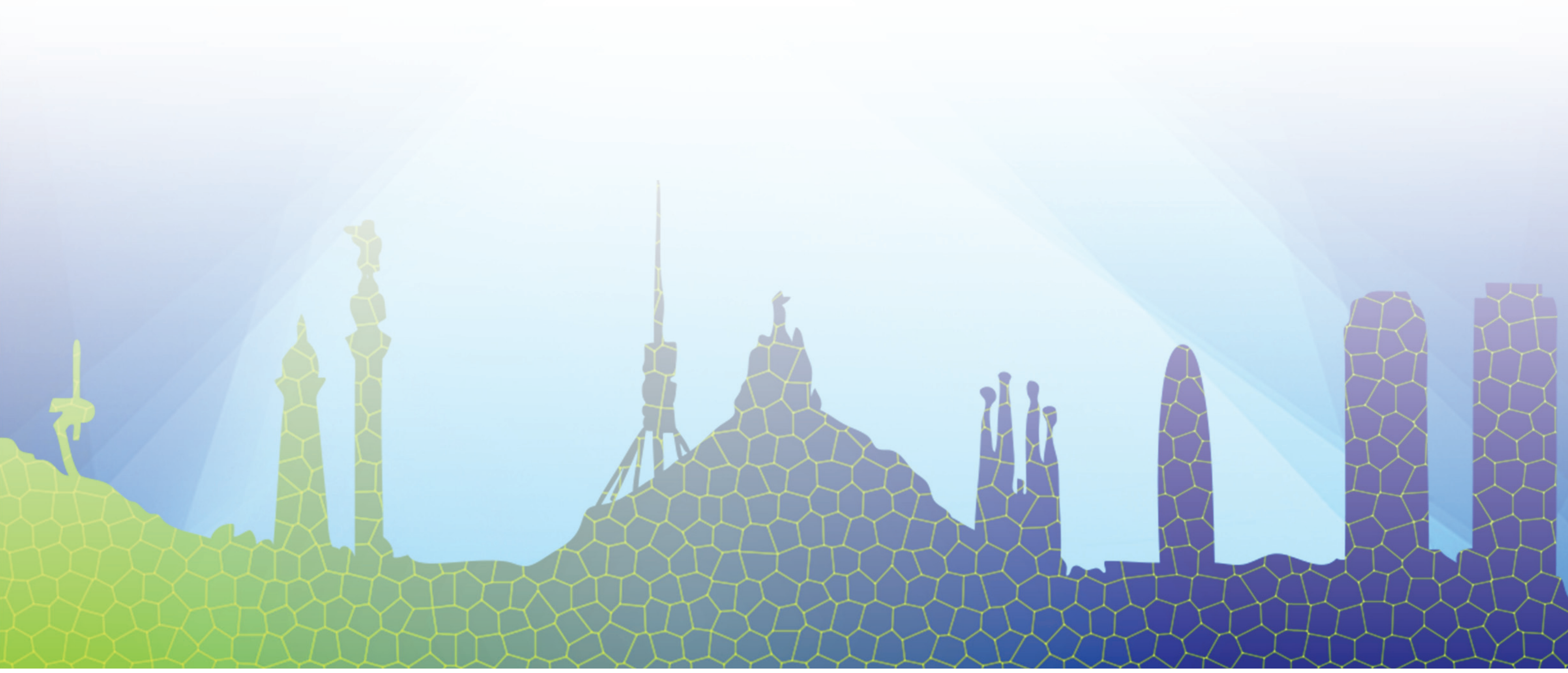

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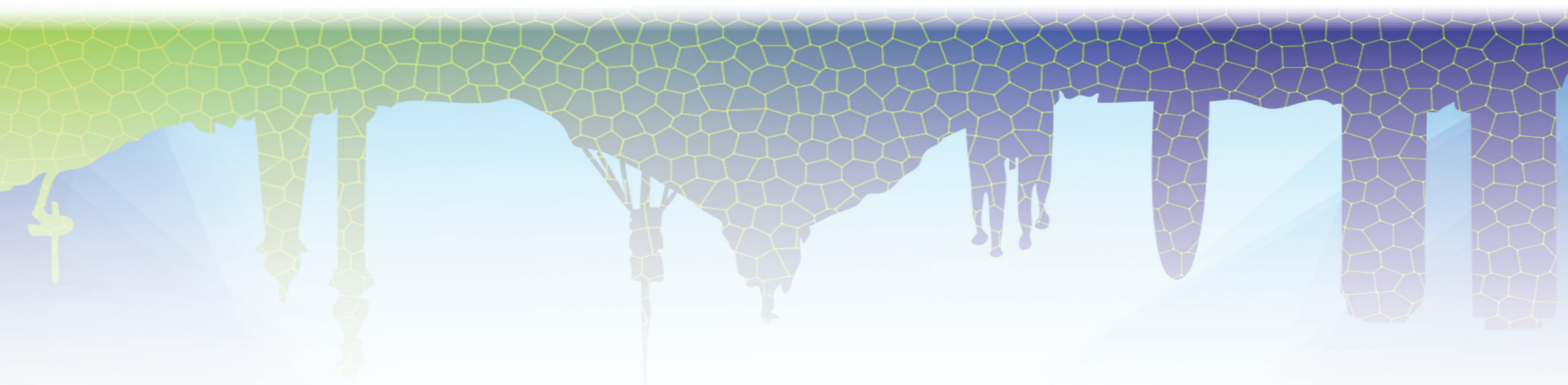

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