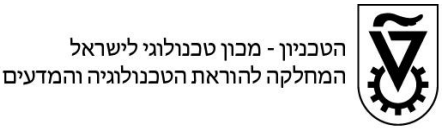
Forward

The ERIDOB Academic Committee has invited researchers in biology didactics to take part in the 10th conference of European Researchers in Didactics of Biology (ERIDOB). The conference is held in Haifa, Israel, June 30th – July 4th, 2014. The aim of the conference is to give researchers in biology didactics the opportunity to present and discuss their research and results. Contributions should fit into one of the following strands:

1. Student conceptions and conceptual change
2. Student interest and motivation
3. Student values, attitudes and decision-making
4. Student reasoning, scientific thinking and argumentation
5. Teaching: teaching strategies, teaching environments
6. Teaching and learning with educational technology
7. Environmental education and Biology education
8. Health education and Biology education
9. Social, cultural and gender issues
10. Practical work and field work
11. Research methods and theoretical issues concerning research in Biology education
12. Teacher training: high school biology
13. Informal / out of school
14. Assessment
15. Curriculum

Sponsors



The city of Haifa

ERIDOB 2014

Academic Committee

Dr. Margareta Ekborg	Malmö University, Sweden (Secretary)
Dr. Dirk Jan Boerwinkel	Utrecht University, Netherlands
Dr. Marida Ergazaki	University of Patras, Greece
Dr. Maria José Gil Quílez	University of Zaragoza, Spain
Dr. Grégoire Molinatti	Universite Montpellier II, France
Dr. Tali Tal	Technion, Israel
Dr. Marcus Grace	Southampton University, UK
Dr. Jörg Zabel	Leipzig University, Germany

Local Organizing Committee

Dr. Tali Tal	Technion, Israel
Dr. Anat Yarden	Weizmann Institute of Science, Rehovot, Israel
Dr. Keren Mintz	Technion, Israel

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The Academic Committee is thankful to the following ERIDOB members who helped in the review:

Iris Alkaher – Israel
Kyriacos Athanasiou – Greece
Orit Ben Zvi Assaraf – Israel
Jelle Boeve-De Pauw – Belgium
Susanne Bögeholz – Germany
Reuven Babai – Israel
Ayelet Baram-Tsabari – Israel
Kerst Boersma – Netherland
Ana Maria Caldeira – Brazil
Claude Caussidier – France
Vaille Dawson – Australia
David Fortus – Israel
Yael Furman Shaharabani – Israel
Niklas Gericke – Sweden
Marcus Hammann – Germany
Ute Harms – Germany
Corinna Hoessle - Germany
Mona Holmqvist Olander – Sweden
Marie-Christine Knippels –Netherlands
Konstantinos Korfiatis – Cyprus
Gili Marbach-Ad – United States
Keren Mintz –Israel
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Kai Niebert – Germany
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Penelope Papadopoulou – Greece
Franz Rauch - Austria
Ronit Rozenszajn - Israel
Kirsten Schlueter – Germany
Marcus Schrenk – Germany
Laurence Simonneaux – France
Ornit Spektor-Levy – Israel
Masha Tsaushu – Israel
Benoît Urgelli – France
Matthias Wilde – Germany
Anat Yarden - Israel
Michal Zion – Israel

Welcome

Dear colleagues,

We are delighted to welcome you to the 10th European Researchers in Didactics of Biology (ERIDOB) bi-annual conference, which is hosted by the Technion - Israel Institute of Technology in Haifa. The beautiful location of the city of Haifa on Mount Carmel along with the rich and stimulating program which was built for this conference, promise you an interesting and enjoyable stay in Haifa.

Approximately two years ago, during the recent ERIDOB conference in Berlin, we were notified that Prof. Pinchas (Pini) Tamir, who was a leading scholar in biology education research since the late 60's and well known amongst the ERIDOB community, passed away. Pini's work focused on research and practice in the context of high school biology in Israel, and was greatly appreciated around the world. We dedicate this ERIDOB conference in Haifa to the late Prof. Tamir, and invited one of his former students, Prof. Anat Zohar, from the Hebrew University in Jerusalem, to give a keynote in his memory at the conference. The program this year includes another keynote on genetics education that will be given by Prof. Ravit Golan Duncan, from Rutgers University in the US, three symposia which will focus on the teaching and learning of energy, on systems thinking, and on current issues in biology education research. The program includes also presentations by all participants, and we hope that altogether it will enable all of us to learn more about our field and about each other.

Approximately 160 proposals were submitted to the conference this year. The Academic Committee, together with other members of the ERIDOB community, peer-reviewed all the proposals and put together the program that is offered to you in the following pages. We are thankful to all the individuals who invested significant time and effort in organizing this conference. We hope you will enjoy the conference and your stay in Israel.

Anat Yarden
Weizmann Institute of Science

Tali Tal
Technion – Israel institute of Technology

ERIDOB 20134 in Haifa, Israel is the second ERIDOB Conference since I was appointed academic secretary. It is a joy and honour to be part of this association and as I have said many times ERIDOB is one the nicest conferences you can attend. The days in Haifa will give opportunities to listen to presentations about research in Biology Didactics, critical discussions and to exchange ideas about research and teaching in school and at university.

I hope that your days in Haifa will be filled with opportunities for meeting and sharing important ideas with old and new colleagues from many countries and that you will leave Haifa full of new ideas and impressions.

Finally I want to thank the organizers for the great job they have done for all of us!

Margareta Ekborg

Academic committee secretary

Venue

The conference is held at the Technion – Israel Institute of Technology, at the city of Haifa.
Sessions will take place in the **Water Institute Building** and in the adjacent **Rabin building** and its extension – **Borowitz building**.
Lunch and Coffee will be served at the Water Inst. Lobby.
Sessions in Rabin building will be at the **Auditorium – ground floor** and in the **Assembly Room in floor 7**.
To go to Borowitz building you have to go to floor 4 in Rabin building and cross to Borowitz building. Sessions will take place on the 5th floor.
If you come to the Technion using public transportation, get off at the Sport Center bus stop. Go through the roundabout and follow the ERIDOB signs. At the middle of the big parking lot take a few steps down The Rabin building and the Water Institute.

Transportation

ERIDOB bus will pick up members from Carmel Center Hotels, (near Dan Panorama Hotel) on 08:15 and from The Theodore Hotel in Hertzel st. on 08:15.
If you wish to use public transportation at your convenience, the following bus lines arrive at the Technion:
Bus # 31 from near Carmel Center Hotels (ask at the reception where the closest bus stop is)
Bus # 19 from near The Bay Club Hotel (allow 30 min)
Bus # 17 from near the Colony hotel (allow 45 min)

Program overview

Monday June 30th, 2014, 19:00-21:00			
Registration and Welcome reception: The Colony Hotel (on the roof), 28 Ben Gurion Ave, The German Colony, Haifa			
Tuesday July 1st, 2014			
8:30-9:00 Morning Coffee			
9:00-9:30		Opening Session **Auditorium, Rabin Building**	
9:30-10:45	**Plenary session**	Keynote speaker: Anat Zohar, Israel. **Auditorium, Rabin Building**	
10:45-11:15	**Coffee break**	**Lobby Water Institute**	
11:15-12:45	**Paper Session 1**	**Symposium 1: Energy Auditorium Water Inst.**	**Strand 3: Borowitz bldg. 5th floor**
12:45-14:00	**Lunch**	**Lobby Water Institute**	
14:00-15:45	**Paper Sessions 2**	**Strand 1: Auditorium Water Inst.**	**Strand 4: Borowitz bldg. 5th floor**
15:45-16:15	**Coffee break**	**Lobby Water Institute**	
16:15-18:00	**Paper session 3**	**Strand 2- Affective and social aspects. Auditorium Water Inst.**	**Strand 5 – Inquiry based science: Teaching strategies and teaching environments. Boroowitz bldg. 5th floor**
Wednesday July 2nd, 2014			
8:30-9:00 Morning Coffee			
9:00-10:30	**Paper session 4**	**Strand 3: Auditorium Water Inst.**	**Strand 7: Conference Room, Rabin bldg. 7th floor**
10:30-11:00	**Coffee break**	**Lobby Water Institute**	
11:00-12:15	**Poster Sessions 1**	**I Auditorium: Water Inst.** **Strand 7: Environmental education in the context of biology** **Strand 13: Informal/out of school** **Strand 8: Health education and biology education**	**II Boroowitz bldg. 5th floor** **Strand 4: Students reasoning, scientific thinking, and argumentation** **Strand 5: Teaching strategies, teaching**

			environments **Strand 11: Research methods**
12:15-13:30	**Lunch**	**Lobby Water Institute**	
13:30-14:45	**Business meeting**	**Auditorium, Rabin Building**	
15:00	**Tours**	**Haifa Sight seeing**	**Towns Association for Environment Quality – Sachnin**
Thursday July 3rd, 2014			
8:30-9:00 Morning Coffee			
9:00-10:30	**Paper session 5**	**Strand 7: Auditorium Water Inst.**	**Strand 12: Conference Room, Rabin bldg. 7th floor**
10:30-11:00	**Coffee break**	**Lobby Water Institute**	
11:00-12:30	**Symposium 2**	**Special ERIDOB symposium: Current issues in biological education research** **Water Inst., Auditorium and Lobby**	
12:30-13:45	**Lunch**	**Lobby Water Institute**	
13:45-14:45	**Plenary session**	Keynote speaker: **Ravit Golan Duncan** **Auditorium Water Institute**	
15:00-16:00	**Poster session 2**	**I Room: Auditorium Water Inst.** **Strand 1: Student conceptions & Conceptual change** **Strand 15: Curriculum**	**II Boroowitz bldg. 5th floor** **Strand 12: Teacher training** **Strand 14: Assessment**
16:00-16:30	**Coffee break**	**Lobby Water Institute**	
16:30-18:00	**Paper session 6**	**Symposium 3: Systems thinking.** **Auditorium Water Institute**	**Strand 5: Conference Room, Rabin bldg. 7th floor**
19:00	**Gala Dinner**	**Madatech (The National Science Center)**	
Friday, July 4th, 2014			
8:30-9:00 Morning Coffee			
9:00-10:30	**Paper Session 7**	**Strand 7: Auditorium Water Inst.**	**Strand 12: Rabin bldg. 7th floor**
10:30-11:00	**Coffee break**	**Lobby Water Institute**	
11:00-12:30	**Paper Session 6**	**Strand 5: Auditorium Water Inst.**	**Strand 7: Rabin bldg. 7th floor**
12:30-13:00	**Closing session**	**Auditorium Water Inst.**	
13:00	**Take away lunch**		

Detailed Program

Monday June 30th, 2014, 19:00-21:00

Registration and Welcome reception: The Colony Hotel (on the roof), 28 Ben Gurion Ave, The German Colony, Haifa

Tuesday July 1st, 2014

8:30-9:00 Morning Coffee

9:00-9:30 Opening Session Chair: **Tali Tal**, Technion, Israel.

Room: Auditorium, Rabin Building

Welcome: Prof. Moshe Sidi, Senior Vice President of the Technion

9:30-10:45 Keynote speaker: **Anat Zohar, Israel.** Title: Inquiry learning in biology education in Israel and its influence on other school subjects

10:45-11:15 Coffee break

11:15-12:45 Paper Session 1

Symposium 1: Energy. Room: Auditorium Water Institute

Chair: Ute Harms, Germany

Energy as a cross-cutting idea: Future challenges and chances for biology education

30 - **Ute Harms, Sebastian Opitz and Knut Neumann, Germany**

Learning about Energy at Primary Level: Biological contexts as a starting point for energy learning?

32 - **David Fortus, Israel**

Assessing the value of curricular coherence for the instruction of energy

34 - **Sebastian Opitz, Ute Harms and Knut Neumann, Germany**

Energy as a cross-cutting concept: empirical testing of the interdisciplinarity of energy understanding in grade 6-12 students
Discussant: Jeff Nordine

Strand 3: Student values attitudes, and decision making Room: Boroowitz bldg. 5th floor

36 - **Merav Siani, Orit Ben-Zvi Assaraf and Moshe Barak, Israel**
An analysis of attitudes and values regarding genetic counseling among Israeli undergraduate students
153 – **Sabina Eggert and Susanne Bögeholz, Germany**
Enhancing students' socioscientific decision making in the biology classroom: the influence of cooperative learning environments
65 - **Marie-Christine Knippels , Chantal de Ruijter, and Arend Jan Waarlo, Netherlands**
Techno-moral-vignettes: A useful tool to introduce synthetic biology related socio-scientific issues
87 - **Dirk Jan Boerwinkel, Anat Yarden and Arend Jan Waarlo, Netherlands, Israel**
Reaching a consensus on genetics literacy needed by a 21st century citizen

12:45-**14:00** Lunch, Lobby Water Institute

14:00-15:45 Paper Sessions 2

Strand 1: Student conceptions & Conceptual change. Room: Auditorium Water Institute
Chair: Marcus Hammann, Germany

1- **Debra Schroder and Edith Dempster, South Africa**
Factors influencing conceptual change when South African learners encounter evolution
90 - **Ran Peleg and Ayelet Baram-Tsabari, Israel**
Children's conceptual change in evolution following an educational science theatre play
12 - **Marcus Hammann, Horst Bayrhuber andRoman Asshoff, Germany**
Students' post-conceptions in Biology: We can diagnose them, but don't have the knowledge to avoid them
39 - **Rosa Branca Cameira Tracana Pereira, Maria Helena Alves and Graça Simões Carvalho, Portugal**
Primary school pupil's conceptions about the excretory system

119 - **Tsipi Franko and Nira Mashal, Israel**
The effects of an intervention program using biology metaphors on hemispheric processing

Strand 4: Students reasoning and scientific thinking. Room: Boroowitz bldg. 5th floor
Chair: Michal Zion, Israel

111 - **Caesar Anton, Israel**
The relationship between cognitive operational stages and higher order thinking skills among 11th class Biology students
154 - **Reuven Babai and Adi Mor Yosef, Israel**
An intervention that accelerates students' inquiry abilities
33 - **Daniela Mahler, Jörg Großschedl and Ute Harms, Germany**
How does Biology teachers' professional knowledge influence system thinking of students?
22 - **Moriya Mor, Michal Zion, Bruria Agrest and Ruth Mendelovici. Israel**
The impact of metacognitive awareness and system thinking instruction on the understanding of the biological core concept homeostasis
75 - **Julia Schwanewedel and Kathrin Klöpfel. Germany**
Students' strategies in processing biological information from texts, pictures and text-picture-combinations

15:45-16:15 Coffee break

16:15-18:00 Paper session 3

Strand 2:Affective and social aspects. Room: Auditorium Water Institute
Chair: Ayelet Baram-Tsabari, Israel

137 - **Natalia Hofferber and Matthias Wilde, Germany**
Influence of teachers' behavior on pupils' motivation
138 - **Melanie Basten and Matthias Wilde, Germany**
Education on organ donation - Inducing an Attitude Change or Bridging an Attitude-Behaviour Gap?
141 - **Andri Christodoulou, Kathryn Woods-Townsend, Jenny Byrne, Marcus Grace, Janice Griffiths and Willeke Rietdijk, United Kingdom**

Meet the Scientist: scientist-student interactions as part of an initiative to promote health and science literacy through science education

70 - **Iris Alkaher and Michal Rekler, Israel**

The relationship between values education and environmental education: Secondary teachers' conceptions and teaching strategies

133 - **Andreas Hadjichambis, Yiannis Georgiou, Demetra Hadjichambi, Kyza Eleni, and Demetrios Mappouras, Cyprus**

Human reproduction – An Inquiry based biology module: 7th-graders students' conceptual understanding, motivation and help-seeking

Strand 5: Inquiry based science: Teaching strategies and teaching environments. Room: Boroowitz bldg. 5th floor

Chair: Laurence Simonneaux, France

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Comparisons & deductions of teacher-students' problems with IBSE

89 - **Tim Kramer, Elmar Stahl and Werner Rieß, France, Germany**

The relationship between epistemic beliefs and systems thinking in biology: Differences in epistemic judgments of German primary and secondary school teachers & changes of epistemic beliefs in a biology course on systems thinking

66 - **Sarah Schmid and Franz X. Bogner, Germany**

Does inquiry learning support long-term memory?

100 - **Nicole Wellnitz and Jürgen Mayer, Germany**

Beyond experimentation: observations and classifications in school science

48 - **Tom Bielik and Anat Yarden, Israel**

Characterizing the development of students' ability to ask questions in an inquiry-oriented program in biology

Wednesday July 2nd, 2014

8:30-9:00 Morning Coffee

9:00-10:30 Paper session 4

Strand 3: Student values attitudes, and decision making, Room Auditorium Water Institute
Chair: Margareta Ekborg, Sweden

129 - **Tasos Hovardas and Konstantinos Korfiatis, Cyprus**
Addressing the social dimension in the study of biological socio-scientific issues
55 - **Marcus Grace, Andri Christodoulou, Kathryn Woods-Townsend, Janice Griffiths and Jenny Byrne, United Kingdom**
Improving classroom-based decision-making about obesity as a socio-scientific issue
98 - **Melanie Werner, Julia Schwanewedel and Jürgen Mayer, Germany**
Students' abilities in decision-making and the influence of socio-scientific contexts and context-person-valences
96 - **Demetra Hadjichambi, Yiannis Georgiou, Andreas Hadjichambis, Hara Ioannou and Constantinos Manoli, Cyprus**
Effectiveness of an Environmental Education Program in Promoting Sustainable Consumption

Strand 7: Environmental education in the context of biology, Room: Conference Room, Rabin bldg. 7th floor
Chair: Orit Ben-Zvi Assaraf, Israel

13 - **Vaille Dawson and Katherine Carson, Australia**
Australian Secondary Students' Understandings of Climate Change
43 - **Nurit Carmi, Israel**
The Impact of Environmental Knowledge, Understanding, and Emotions on Environmental Behavior
6 - **Benjamin Steffen and Corinna Hoessle, Germany**
Assessing students' evaluation and judgment competence regarding climate change - concepts of biology and political education teachers
113 - **Steffen Schaal, Anabel Haas, Armin Lude and Sonja Schaal, Germany**
BioDiv2Go - Using geogames to foster biodiversity

10:30-11:00 Coffee break, Lobby Water Institute

11:00-12:15 Poster Sessions 1

I Auditorium: Water Institute
Chair: Marida Ergazaki, Greece

Strand 7: Environmental education in the context of biology
25 - **Keren Mintz and Tali Tal, Israel**
How can higher education contribute to the development of sustainability literacy? The case of an Israeli university
41 - **Jean Simonneaux, Fanny Leboucher and Marie-Angelina Magne, France**
Using a serious game to encourage the design of innovative environmentally friendly agricultural systems
150 - **Martin Jurgowiak and Jörg Zabel, Germany**
The natural history perspective on bio-communities – using monographs in ecology education
126 - **Katja Feigenspan, Germany**
Understanding of nature, sustainability and ESD by prospective Biology teachers
135 - **Marianna Kalaitzidaki, Christina Pantechi and Maria Ivrinteli, Greece**
Plant content of Greek elementary study of the environment textbooks
92 - **Esti Laslo and Ayelet Baram - Tsabari, Israel**
Expressions of science literacy in authentic online public discussions following climate change news coverage

Strand 13: Informal/out of school
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Novel extracurricular settings: How do pupils handle lack or provision of structure

Strand 8: Health education and biology education
102 - **Carolin Retzlaff-Fürst, Germany**
A school garden as a location of health education: Green cheers you up
81 - **Diana Garasic, Ines Radanovic and Zaklin Luksa, Croatia**
Croatian students interest in health-related topics

II Boroowitz bldg. 5th floor
Chair: Grégoire Molinatti, France

Strand 4: Students reasoning, scientific thinking, and argumentation

3 - **Birgitta Berne, Sweden**
Progression in ethical reasoning when addressing socio-scientific issues in Biotechnology
53 - **Nina Christenson, Niklas Gericke and Shu-Nu Chang Rundgren, Sweden**
A cross-disciplinary approach to teaching socioscientific issues – A study of the co-operation between language and science teachers teaching about global warming
24 - **Nadia Cancian and Laurence Simonneaux, France**
Developing students' socioeco agronomic reasoning on pesticide reduction
130 –**Anne Nitsch, Sabina Eggert, Susanne Bögeholz, and Matthias Nückles, Germany**
Using concept maps to foster students' understanding and socioscientific reasoning about climate change

Strand 5: Teaching strategies, teaching environments
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A study on scientific inquiry through experiments in biology teaching - teachers` practices and views
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Supporting outdoor inquiry by mobile technology
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Prospective Biology teachers' competence to assess pupils' abilities to experiment

Strand 11: Research methods
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67 - **Alice Veldkamp, Paul van der Zande, Harrie Eijkelhof and Marie-Christine Knippels, Netherlands**
In search of a biology-specific pedagogy for initial teacher education in the 21st century
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Experimentation with gradually increased self-regulation: Is it beneficial for students' motivation?

12:15-13:30 Lunch, Lobby Water Institute

13:30-14:45 Business meeting, **Room: Auditorium, Rabin Building**

15:00 Tours

Thursday July 3rd, 2014

8:30-9:00 Morning Coffee

9:00-10:30 Paper session 5

Strand 7: Environmental education in the context of biology: Environmental attitudes and motivation. Room: Auditorium Water Inst.
Chair: Franz Bogner, Germany

52 - **Jelle Boeve-De Pauw and Peter Van Petegem, Belgium**
The effect of schools' environmental policy making on the ecological values and motivation of students and teachers
60 - **Franz X. Bogner and Michael Wiseman, Germany**
The 2-MEV model and beyond: Towards Quantifying Environmental Citizenship
62 - **Anne K. Liefländer and Franz X. Bogner, Germany**
Towards acquiring pro-environmental attitudes through environmental education: Do age and sex cause effects?
63 - **Olivia Dieser and Franz X. Bogner, Germany**
Exploring nature and biodiversity: Intervention of a residential week-long field course with adolescents attitudes knowledge and behaviour

Strand 12: Teacher training: High school biology. Room: Conference Room, Rabin bldg. 7th floor
Chair: Marcus Grace, UK

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Concerns of experienced Biology teachers
16 - **Ronit Rozenszajn and Anat Yarden, Israel**
Tacit relationships between biology and mathematics teachers content knowledge (CK) and their pedagogical content knowledge (PCK)
40 - **Penelope Papadopoulou, Efstratios Katakos and Kyriacos Athanasiou, Greece**

A qualitative analysis of the factors making the conceptual ecology of the evolution theory in Greek secondary school teachers

82 - **Eija Yli-Panula, Christel Persson and Heini Pollari, Finland, Sweden**

The consciousness of the Finnish and Swedish pre service teachers of the relationships of the concepts - species identification, biodiversity and sustainable development

26 - **Jörg Großschedl, Daniela Mahler, Ute Harms and Thilo Kleickmann, Germany**

Biology teachers' content-related knowledge: structure and learning opportunities

10:30-11:00 Coffee break, Lobby Water Institute

11:00-12:30 Symposium 2: Special ERIDOB symposium: Current issues in biological education research

Organizers and chairs: Dirk Jan Boerwinkel (Netherlands) and Marcus Grace (UK)

Room: Water Inst., Auditorium and Lobby

The symposium will engage the participants in small group discussions facilitated by the chair based on pre-circulated contributions from leading researchers from different countries.

Contributors: Jimenez AleixandreMaría Pilar& Graça Carvlaho (Spain and Portugal), Horst Bayrhuber (Germany), Niklas Gericke& Christina Ottander (Sweden), Dirk Krüger (Germany), Michael Reiss (UK), Laurence Simonneaux & Jean Simonneaux (France), Arend Jan Waarlo (Netherlands), Anat Yarden & Michal Zion (Israel), Vassiliki Zogza (Greece).

12:30-13:45 Lunch break, Lobby Water Institute

13:45-14:45 Keynote speaker: **Ravit Golan Duncan** (United States):**Reasoning in genetics: concepts, practices, and a learning progression. Room: Auditorium Water Institute**

15:00-16:00 Poster session 2

I Room: Auditorium Water Institute
Chair: Maria José Gil Quílez, Spain

Strand 1: Student conceptions & Conceptual change

23 - **Amauri Bartoszeck, Sandra de Lus and Sue Dale Tunnicliffe, Brazil, United Kingdom**
Secondary school pupils´ conceptions of synaptic transmission by means of drawings: an exploratory study

94 - **Zohar Snapir, Catherine Eberbach, Orit Ben-Zvi Assaraf, Cindy Hmelo-Silver, Jaklin Tripto and Miriam Amit, Israel, United States**
Characterizing the development of understanding the human body Systems in 10th Grade Biology Students

122 - **Georgios Ampatzidis and Marida Ergazaki, Greece**
Can the idea of the balanced nature be effectively challenged in the context of a model-based learning environment? Insights from the 2nd cycle of a developmental research

127 - **Konstantinos Korfiatis, Stella Petrou and Maria Photiou, Cyprus**
The impact of an ecology unit on secondary students' conceptions about natural sightseeing

124 - **Rianne Pinxten, Belgium**
Knowledge and misconceptions of natural selection among science students and biology graduates in university education

Strand 15: curriculum

8 - **Rachel Cohen and Fatin Azar, Israel**
Junior high school science and technology teachers' attitudes regarding mentors and mentor contribution to the assimilation of curricular changes

II Boroowitz bldg. 5th floor
Chair: Jörg Zabel, Germany

Strand 3: Student values attitudes, and decision making, Room Auditorium Water Institute

139 - **Stella Magid, Israel**
Enhancing the authenticity of inheritance in biology subject through socio-scientific issues and values in biology education

Strand 12: Teacher training

7 - **Sascha Hasse and Marcus Hammann, Germany**

Teaching competencies in experimental lessons – Modeling and development of a test instrument

143 - **Christiane Hüfner and Matthias Wilde, Germany**

(Prospective) biology teacher's subjective theories about self-directed learning (sdl)

148 - **Sabrina Mathesius, Germany**

Evaluation of pre-service science teachers' competencies in scientific inquiry using multiple-choice items

19 - **Maria J. Gil Quilez and Begoña Martinez Peña, Spain**

Why do these beans smell? Explanation of a complex phenomenon by teacher trainees

69 - **Frank Rosenkraenzer, Werner Riess, Elmar Stahl and Christian Hoersch, Germany**

Pedagogical content knowledge of teacher students for promoting systems thinking

Strand 14: Assessment

73 - **Yvonne Schachtschneider, Vanessa Pfeiffer, Silvia Wenning and Angela Sandmann, Germany**

Assessment of students´ biological knowledge and personal traits when beginning to study life sciences at university – Instrument development and first results

16:00-16:30 Coffee break, Lobby Water Institute

16:30-18:00 Paper session 6

Symposium 3: Systems thinking. Auditorium Water Institute

Organizer and chair: Werner Riess, Christian Hörsch, Tim Kramer, Germany

64 - **Stefan Streiling, Werner Riess and Christian Hörsch, Germany**

Promoting systems thinking in the biology class - effectiveness of teacher training

71 - **Daniela Fanta, Julia Braeutigam, Werner Riess and Stephan Schuler, Germany**

Teaching systems thinking: Evaluating an intervention for biology and geography students

78 - **Rainer Mehren, Armin Rempfler, Janine Buchholz, Johannes Hartig and Eva Marie Ulrich-Riedhammer, Germany, Switzerland**

System Competence Modelling

74 - **Orit Ben-Zvi Assaraf, Adi Keynan and Daphne Goldman, Israel**
A Place-Based Approach to Enhancing 7th-9th grade students' systems thinking and understanding of biodiversity

Strand 5: Teaching strategies, teaching environments.
Room: Conference Room, Rabin bldg. 7th floor
Chair: Konstantinos Korfiatis, Cyprus.

54 - **Ruth Zuzovsky and David Mioduser, Israel**
Learning about ecological systems with DynaLearn - A qualitative modeling tool
18 - **Masha Tsaushu, Israel**
Towards deep learning: The contribution of an innovative instructional model
77 - **Gili Marbach-Ad, United States**
Use of a concept inventory to probe student learning and to inform faculty professional development
99 - **Martin Remmele and Andreas Martens, Germany**
The impact of stereoscopic 3-D on constructing and correlating multiple external representations of a human biological topic

19:00 Gala Dinner, Madatech (The National Science Center). Busses will take all participants from the Technion

Friday, July 4th, 2014

9:00-10:30 Paper Session 7

Strand 7:Environmental education in the context of biology. Room: Auditorium Water Inst.
Chair: Marie Christine Knippels, The Netherlands

106 - **Jose Ramon Diez, Jaume Ametler and Sukarrieta Taldea, Spain**
Are students' conceptions about environmental topics changing? A comparative study between 1995 and 2013 of students' previous ideas about water cycle
27 - **Idit Adler, Michal Zion, Zemira Mevarech and Irit Sadeh, Israel**

A Metacognitive-based Instructional Model Designed to Develop Environmental Literacy

58 - **Martha-Daniela Queren and Carolin Retzlaff-Fürst, Germany**

Agro-biodiversity in science lessons - implementation and evaluation of a lesson concept to develop the students' aesthetic judgment exemplified by the soybean

108 - **Yelva C. Larsen, Jorge Groß and Franz X. Bogner, Germany**

Student-monitored learning for sustainable development - does it bridge the gap between formal and informal science education

Strand 12: Teacher training. Rabin bldg. 7th floor

Chair: Vasiliki P. Zogza, Greece

42 - **Moritz Krell, Germany**

Biology teachers' conceptions about models and modelling in science

44 **- Daphne Goldman, Sara Pe'Er and Bela Yavetz, Israel**

Sustainability and environmental education for sustainability in teacher training - perceptions of pedagogue instructors

110 - **Grégoire Molinatti and Ariel De Bernardo, France**

Teachers' processes involved elaborating media corpus to treat the GMOs socioscientific issue within the classroom

114 - **Ornit Spektor-Levy, Yael Kesner-Baruch and Anat Abramovich, Israel**

From "Hesitant" to "Environmental Leader" – The influence of a professional development course on environmental citizenship of pre-school teachers

10:30-11:00 Coffee break, Water Inst. Lobby

11:00-12:30 Paper Session 6

Strand 5: Teaching strategies, teaching environments (Language issues), **Room: Auditorium Water Inst.**

Chair: Vaille Dawson, Australia

21 - **Jennifer Härting, Gustav Bohlin, Ute Harms, Anja Nordbruch, Daniel Orraryd and Lena Tibell, Germany, Sweden**

How to evaluate visualizations on evolution? An initial analysis using a criteria catalogue including threshold concepts

51 - **Galia Zer Kavod and Anat Yarden, Israel**
Developing adapted primary literature modeling device for scientific writing in high-school
95 - **Karin Thörne and Niklas Gericke, Sweden**
How secondary teachers verbally relate the words gene, DNA and chromosome when teaching genetics
151 **- Tania Goldbach, Marisa Costa Gomes, William Alves Pereira, Laion Victor Oliveira Okuda and Beatriz Dos Anjos F.S. Da Silva, Brazil**
The potential of text from scientific vulgarization magazines for the innovation of genetics approaches in school context

Strand 7: Environmental education in the context of biology. Rabin bldg. 7th floor
Chair: Niklas Gericke, Sweden

136 - **Chagit Tishler, Orit Ben- Zvi Assaraf and Michael N. Fried, Israel**
How families make sense of biology at the zoo: the role of questions and questioning
5 - **Laurence Simonneaux and Amélie Lipp, France**
The effects of a socially acute question on the evolution of the biological sciences curricula: the case of farm animal welfare
46 - **Lilian Daniel and Tali Tal, Israel**
Towards education for sustainability in an Arab school in Israel - A case study
131 - **Stella Petrou, Konstantinos Korfiatis and Maria Photiou, Cyprus**
Investigating pre-service teachers' environmental values through environmental scenarios

12:30-13:00 Closing session
Chair: **Anat Yarden**, The Weizmann Institute, Israel. **Room: Auditorium Water Inst.**

13:00 Take away lunch

ABSTRACTS

(By alphabetical order of first author' name)

27. A Metacognitive-based Instructional Model Designed to Develop Environmental Literacy

Idit Adler, Michal Zion, Zemira Mevarech and Irit Sadeh

The article presents an instructional model aimed at increasing environmental literacy by metacognitive-based learning processes. The fundamental part of this model is the development of metacognition, which refers to the ability to reflect upon, understand, and control one's learning. At the core of the model is inquiry based learning, an environment that provides scaffolding for the development of metacognition. The embedded metacognitive instruction addressed the individual and social aspect of metacognition .

An experiment was conducted to examine the model. The research population consisted of 324 high-achieving 7th and 8th grade students, which were involved in open environmental inquiry projects over the course of a full academic year, and documented them in reports. The data presented in this study is based on 131 reports. Students were divided into four research groups according to the metacognitive instruction method to which they were exposed: individual and social metacognitive instruction; social metacognitive instruction only; individual metacognitive instruction only; and a control group. The reports' 'Introduction' and 'Summary' chapters, which included the students' personal perspective and reflection on their inquiry process, were examined using an Environmental Literacy Inventory (ELIN) which was developed for this purpose. The ELIN is based on the four strands of environmental literacy and on environmental associated variables as described by research in the field. We conducted binary coding according to the ELIN, followed by the development of a personalized description for each student, which was analyzed using qualitative and quantitative methods .

Within the knowledge strand, results demonstrate no significant group difference in the types of knowledge mentioned in students' inquiry reports. Within the affect strand, students that received both individual and social instructions mentioned significantly more environmental values and attitudes than other groups, while internal locus of control and emotional involvement were mentioned significantly more by students who received individual metacognitive instruction only. Emotional involvement was also mentioned significantly more in projects of the groups that received social metacognitive instruction than in the projects of the groups that did not. Both environmental associated skills and environmental behaviors were mentioned significantly more by students who received individual metacognitive instruction only .

At the theoretical level, the study established a link between metacognitive awareness and environmental literacy. At the practical level, the study highlights the importance of

developing metacognitive awareness within environmental education, and emphasizes the significance of combining the two aspects of metacognition into environmental programs.

70. The relationship between values education and environmental education: Secondary teachers' conceptions and teaching strategies

Iris Alkaher and Michal Rekler

Values education is important to the development of responsible, involved citizens. Effective environmental education (EE) is widely agreed to be based on sociocultural values. According to recent Israeli Ministry of Education recommendations, teachers should embed social values in their teaching. We focused on secondary school teachers from different disciplines who follow this recommendation .

The recent rise in Israeli public environmental awareness has resulted in environmental topics being incorporated into school curricula. However, many teachers were not systematically trained in effective pedagogic methods to incorporate EE into their teaching. This study assumed that secondary school teachers who integrate values into their teaching may have opportunities but lack necessary skills to connect them to environmental values. We aimed to investigate those teachers' awareness of the connection between the sociocultural values and environmental issues, and to the pedagogical implications of such connections .

The study was conducted in an urban public secondary school in southern Israel. 27 teachers from various disciplines, who reported that they incorporate values in their teaching, participated in the study. We administered questionnaires assessing teachers' conceptions regarding values education and EE and identifying specific values incorporated into their teaching. Data were quantitatively and qualitatively analyzed. We also analyzed semi-structured interviews with teachers to clarify why and how they connect values to environmental issues .

We found great variability in the sociocultural values integrated by teachers in their work. 70% claimed they incorporate values because they view moral education as the core of teaching. Although the concept that environmental issues are interdisciplinary, and that all teachers need to address environmental issues was generally accepted, only 59% actually claimed that they connected values to environmental topics. Although only 12% regarded EE as a science-centered topic to be taught by science teachers, all the non-biology teachers reported discomfort integrating environmental aspects into class, claiming insufficient environmental knowledge. Those who connected values-based topics to environmental issues did so in three ways: Focusing on dilemma-centered discourse, directing text-based learning into ethical socio-environmental discourse and involving students in the community .

Most teachers identified connections between values-education and EE, which implies teachers' awareness and understanding of environmental issues as sociocultural in nature. Their willingness to expand their environmental knowledge highlights the need to develop educational programs to provide teachers from different disciplines the relevant knowledge

and skills. Ongoing support may increase teachers' confidence while addressing environmental implications of the values they anyway seek to embed in their teaching.

122. Can the idea of the balanced nature be effectively challenged in the context of a model-based learning environment? Insights from the 2nd cycle of a developmental research

Georgios Ampatzidis and Marida Ergazaki

This paper reports on insights from the second cycle of a developmental research aiming at the design of a learning environment that could effectively support non biology-major students (a) in challenging the widespread view of the 'balanced nature' and constructing a meaningful, up-to-date understanding about how ecosystems may function, and (b) in using this understanding to enhance their systems thinking skills. Our focus here is set on (a) and particularly on (1) whether and how students' reasoning about the ways ecosystems may respond to human-driven disturbance or protection has been altered after their engagement in the second version of our learning environment, and (2) whether this new version that has been re-designed based on the feedback from the 1st cycle of the study seems to be more effective than the previous. Considering social constructivism and problem-posing approach, we developed a computer-supported, collaborative learning environment for highlighting ecosystems' contingent behaviour through the currently valid idea of the 'resilient nature'. Thirty-four, 1st-year students of educational sciences were actively introduced to the basic assumptions of this idea in five, 2-hour sessions within an optional course of ecology. In each session students collaborated in triads to explore a 'NetLogo' model. The four models we developed simulated terrestrial or aquatic ecosystems faced with internally or externally triggered changes. Each model had two versions showing two different trajectories of an ecosystem. These were linked to differences in initial conditions or human actions for its recovery. Half of the triads explored the first version, while the other half the second, with the aid of worksheets. These required predictions about the ecosystem's behaviour before using the model and explanations afterwards. The two different trajectories shown in the two versions of each model were discussed in whole class discussions at the end of the sessions. In the fifth session, students were engaged in reasoning about ecosystems' behaviour through 'landscape models' made of plasticine and cardboard and hands-on activities concerning systems thinking. Students filled in a pre/post-questionnaire, the first part of which included five, open-ended items about the behaviour of protected or disturbed ecosystems. These aimed at probing the target assumptions of the 'resilient nature' and their use as warrants for nature's contingent behaviour. Preliminary results from the analysis of students' responses to some items with 'NVivo' - a qualitative-analysis software -, as well as their comparison to the results obtained from the 1st cycle of the study are discussed.

12. Students' Post-conceptions in Biology: We can diagnose them, but don't have the knowledge to avoid them

Roman Asshoff, Horst Bayrhuber and Marcus Hammann

The authors surveyed the literature on student conceptions to (i) identify major student conceptions in NOS; cell biology, physiology, genetics, ecology, evolution and organismic biology and (ii) communicate them to biology teachers through a book publication. The present paper draws on this survey. Its focus lies on studies concerned with diagnosing student conceptions. Rather than summarizing the book, this paper focuses on theoretical issues to develop the field further. The argument is made that it is helpful to distinguish between pre-conceptions (i.e. student conceptions that can be found in students before they are taught a topic) and post-conceptions (i.e. conceptions found in students after teaching). The latter form the vast majority of student conceptions in biology. However, studies of post-conceptions give little information, if any, on specific classroom practices which contribute to the formation of post-conceptions. This lack of information severely limits the educational implications of this type of research .

In a few selected studies, however, explicit connections between classroom practices and post-conceptions are made. These examples are crucial because testable hypotheses can be derived from them. On the one hand, there is evidence that teaching at times addresses specific aspects but leads to unintended post-conceptions. For example, research documented the post-conception that atoms consist of cells, i.e. protons, electrons and neutrons. This might go back to fragmented knowledge acquired in two isolated units on the structure of matter and the cell as the basic unit of life. On the other hand, there is evidence that teaching at times fails to address specific aspects and therefore leads to unintended post-conceptions. For example, students think that two-chromatid chromosomes form through fertilization because – very likely – classroom instruction failed to address the process of identical reduplication. The majority of the studies concerned with diagnosing student conceptions, however, does not relate post-conceptions to previous teaching, which renders it difficult – if not impossible – to discuss the educational implications of the findings .

Research concerned with student conceptions can be developed further by focusing on the interactions between classroom practices and student post-conceptions. Building on the strengths of the past phase – the availability of test instruments to diagnose student conceptions – researchers should use teaching experiments (and similar formats) to test specific hypotheses about how unintended post-conceptions can be avoided. Rare examples of this type of research that point into this direction, like breaking a bar of chocolate into two pieces in the context of cell division, will be discussed.

154. An intervention that accelerates students' inquiry abilities

Reuven Babai and Adi Mor Yosef

One major aim of the biology curriculum is the promotion of scientific reasoning, in which inquiry abilities play an important role. These reasoning abilities are important for example,

in order to draw conclusions and design experiments, yet students' difficulties in this domain have been observed in numerous studies. The current study addresses these difficulties from the cognitive development perspective. We addressed these difficulties through a short intervention of six sessions taken directly from the CASE program (Cognitive Acceleration through Science Education). The full CASE program of 30 lessons is known to accelerate students' cognitive development and to have a long-lasting positive effect on their academic achievements. We explored whether such intervention that focuses on acceleration of the control of variables reasoning scheme and several relevant abilities tightly related to inquiry that are embedded in these sessions, would have a positive effect on ninth graders' inquiry abilities.

Taking part in the study were 151 ninth graders from five classes. Three classes were randomly chosen to serve as an intervention group and the other two classes as a control group. In the control group inquiry abilities were taught in a traditional way, according to the current curriculum, for the same amount of time as in the intervention group. A general science exam and a cognitive level assessment test were carried out prior to the intervention and an inquiry abilities posttest in biology was administered post-intervention.

The findings indicate that the short CASE intervention had a significant positive effect on students' inquiry abilities. Further analysis revealed that the significant benefit of the intervention took place in the three Piagetian developmental levels detected in this study (the concrete developmental stage, a transition stage from concrete to formal operations levels, and the formal developmental stage).

Overall, the study showed that the short intervention that was aimed at accelerating inquiry abilities by using six CASE sessions has a positive effect on students' performance. In addition, we suggest that science educators should pay more attention to limitations related to students' cognitive levels when addressing scientific reasoning.

23. Secondary school pupils´ conceptions of synaptic transmission by means of drawings: an exploratory study

Amauri Bartoszeck, Sandra de Lus and Sue Dale Tunnicliffe

An important objective of primary and secondary school Biology (basic Physiology) teaching and learning is an understanding by the teacher that pupils' previous ideas might contribute to their learning of subject contents. Eliciting their mental models of what they consider to be a synapse and synaptic transmission by means of analyzing drawings with the help of a rubric scale, is a better way to try to understand pupils views manifested by pictorial representations. A rubric scale was developed inspired on Luquet´s study of children´s drawings (Luquet, 1927/1979). This study investigated pupils from 14 years to 17 years (N=178) from a rural area sample in Brazil, through drawings and interviews. Findings indicate that although synapses features are depicted on the drawings pupils are in doubt what kind of current flows across the synaptic cleft and have scant idea of synaptic

potentials and neurotransmitters. Educational implications are suggested into the urgent adoption of practical classes and computer simulations to cover this knowledge gap.

138. Education on organ donation - Inducing an Attitude Change or Bridging an Attitude-Behaviour Gap?

Melanie Basten and Matthias Wilde

The German legal regulation wants potential donors to be self-determined and consent to organ removal solely out of solidarity (BÄK, 2011; Vollmann, 2012). The decision is bipolar (consent or refusal) and is not officially registered but stated on an organ donor card. Representative surveys had found that a high percentage of the German population (74%) was in favour of donating but only few people (25%) held an organ donor card (attitude-behaviour gap) (Watzke & Stander, 2010). Therefore, the donor rule was amended in 2012 to recruit more potential donors or at least unburden next-of-kin and medical personnel by a clearly stated decision (Decision Solution; BMG, 2012). Since November 2012 health insurance companies send brochures on organ donation and organ donor cards to every German resident aged 16 years or older. The individual decision that has to be made requires the competence to judge on the topic (KMK, 2004). The aim of the current studies was to evaluate educational interventions using donor cards for take-away and information provided by the Federal Centre for Health Education (BZgA). The research question was whether lessons with the film in comparison to a neutral PowerPoint presentation covering the same contents either reduced the attitude-behaviour gap or (additionally) induced an attitude change. In two studies with pre- and post-test designs, students aged 16 were educated about organ donation and their attitude and behaviour were assessed. The results showed that the attitude-behaviour gap could be reduced. In the post-test significantly more students held an organ donor card. Students made use of both options (consent and refusal) with more students refusing organ removal in study 2 that was conducted after the Decision Solution came into effect and several organ-trafficking scandals had taken place (DSO, 2012). However, no students were persuaded but the students that carried a donor card after the intervention had had a more positive attitude before the lessons. When analysing the students that agreed and refused organ removal separately, it was shown that the students refusing organ removal had had a negative (study 1) or neutral (study 2) attitude before the intervention. With regard to the amended donor rule (Decision Solution) it seems to be effective to provide information and organ donor cards in order to enable people to implement a behaviour they wanted to carry out in any case.

74. A Place-Based Approach to Enhancing 7th-9th Grade Students' Systems Thinking and Understanding of Biodiversity (Symposium: Systems Thinking)

Orit Ben Zvi Assaraf, Adi Keynan and Daphne Goldman

There is accumulating evidence that comprehension of complex systems is essential for in-depth understanding of environmental issues, such as those related to human impact on

biodiversity. In-depth understanding of ecosystem function – the mechanisms which are the essence of the self-organization of ecosystems and render them sustainable systems - is a crucial component for the comprehension of biodiversity issues. The study presented here included 20 students, in grades 7-9, who live in villages located in the arid Arava region of Israel. All of them voluntarily participated in an after school science program that included 3 labs, three field trips for inquiry-based study within the ecological system at the Shezaf Nature Reserve, followed, with drawings of the ecological system as one component of knowledge integration activities. In this study, we assessed the impact of studying biodiversity in a place-based educational framework on the students' systems thinking skills, using students' drawings as ''windows'' to their conceptual knowledge. Drawings are one of several meaningful tools that can be used to assess scientific conceptual knowledge and reasoning abilities .

Qualitative analysis of students` drawings showed that the program developed a more complex view of the ecological system at the Shezaf Nature Reserve, both in the hidden dimension and temporal dimension. The students also learned to generalize some of the ecological phenomena, leading to improved understanding of the interactions between humans and their environment, a tool that may help them cope better with complex environmental issues related to biodiversity.

3. Progression in Ethical Reasoning when Addressing Socio--scientific Issues in Biotechnology

Birgitta Berne

This paper reports on the outcomes of an intervention in a Swedish school in which the author, a teacher-researcher, sought to develop students' (14-15 years old) ethical reasoning in science through the use of peer-discussions about socio-scientific issues (SSIs). Prior to the student discussions varied prompts were used to highlight different aspects of the issues. In addition, students were given time to search for further information themselves. An analysis of students' written arguments about cloning and 'design of babies' from before, and after, a teaching intervention showed that in their arguments many students' appear to be moving away from their use of everyday language to using scientific concepts. They also moved from considering cloning and 'design of babies' solely in terms of the present to considering them in the future. Furthermore the students started to approach the issues in additional ways using consequentialism but also the approaches of virtue ethics and rights and duties. Students' progression in ethical reasoning could be correlated to the characteristics of the interactions in peer-discussions. Students that in the peer-discussion critically and constructively argued with each other's ideas and challenged each other's claims made progress in more aspects of ethical reasoning than students using merely cumulative talk. As such the work provides strong and valuable indications for the importance of introducing peer-discussions about SSIs in connection to biotechnology into the teaching of science in schools.

48. Characterizing the development of students' ability to ask questions in an inquiry-oriented program in biology

Tom Bielik and Anat Yarden

Asking questions is a fundamental scientific practice which directs students' learning and knowledge construction, fosters communication, helps self-evaluating their understanding and increases their motivation and curiosity. Authentic scientific inquiry should provide an opportunity for developing students' ability to ask questions and enable students to practice the use of the scientific language. In this research we set to characterize the development of the ability to ask questions by students participating in the 'Bio-Tech' inquiry-oriented program. Our research question is how does the participation in the Bio-Tech program influence students' ability to ask questions, focusing on possible changes in the percentage of researchable questions, on questions that focus on an experiment presented to the students in a popular article, and on students' ability to use metalanguage of science in their questions. Pre- and post-questionnaires were administrated to classes of 11th grade biotechnology students, either participating or not participating in the Bio-Tech program. Following reading an unfamiliar popular scientific article, students were asked to write new scientific questions that interest them. Students' questions were statistically analyzed and classified into the categories of questions that concern the experiment presented in the article and researchable questions. Metalanguage of science terms that were found in students' questions were also statistically analyzed. A similar significant increase in the students' ability to formulate researchable questions was found in both the Bio-Tech and Control groups. An increase was observed in the Bio-Tech students' percentage of questions regarding the experimental process described in the article and in the average number of metalanguage of science terms used by the students. These results indicates that participation in the Bio-Tech program contributed to the students' question-asking ability, mostly to their ability to use metalanguage of science terms and to their ability to focus their questions on the experimental process described in a popular scientific article. This is important for advancing the teaching and learning of science in general and the teaching and learning of this practice in inquiry-oriented educational programs in particular.

87. Reaching a consensus on genetics literacy needed by a 21st century citizen

Dirk Jan Boerwinkel, Anat Yarden and Arend Jan Waarlo

The distance between our understanding of genetics and genetics education has increased, leaving students unprepared for decisions made possible by new developments. A three step Delphi study was undertaken in which 57 international experts were asked to formulate what knowledge of genetics is relevant for all citizens. The answers were classified using the PISA science framework for 2015 to three knowledge types: conceptual knowledge, epistemic knowledge and procedural knowledge. Conceptual knowledge was further categorized using the framework proposed by Duncan, Rogat and Yarden, while epistemic and procedural knowledge were categorized according to criteria that emerged

from the data, resulting in a draft document. In the next phase, six authentic case studies, describing situations in which citizens are confronted with the need to use genetic knowledge were discussed with the participating experts. Each group selected which genetics literacy was needed in the specific case and compared this with the draft document. The resulting comments are used to make an improved definition of genetics literacy to be discussed in the final round .
In the 1st round responses classified under Conceptual knowledge were further classified following Duncan et al. (2009) to two big ideas: i) All organisms have genetic information that is universal and specifies the molecules that carry out the functions of life. While all cells have the same information, cells can regulate which information is expressed; ii) There are patterns of gene transfer across generations. Cellular and molecular mechanisms drive these patterns and result in genetic variation. The environment interacts with our genetic makeup leading to variation. New elements concerned differences between somatic and germ line, genetic variation and polygenic inheritance. The required genetics literacy differed importantly between the cases. Knowledge classified as epistemic knowledge proved to consist of two parts; a.understanding of the 'Nature of Science'-part of genetics, explaining why some predictions are certain and others uncertain; b.understanding techniques and applications of new genetic knowledge and issues in which people are confronted with new decisions. Procedural knowledge proved also to exist of two parts. Communication skills include both the interpretation of genetic information from different sources. Argumentation and decision making skills are needed for democratic discourse and personal and societal weighing of genetic knowledge with values and emotions. General consensus exists on more emphasis on the complex interaction of many genes and environmental factors in the development of most traits, with consequences for the role and place of Mendelian genetics.

52. The effect of schools' environmental policy making on the ecological values and motivation of students and teachers

Jelle Boeve-De Pauw and Peter Van Petegem

The results of a long running quantitative study focusing on the educational effectiveness of the eco-schools program in Flanders (Belgium) will be presented. Eco-schools are schools that aim to improve the environment through direct and indirect effects. Direct effects are those that result from the implementation of an environmental management system. Indirect effects are educational gains; changes in students' psychological traits. The current study examines the effect of eco-schools on students' and teachers' ecological values (2-MEV) and motivation towrds the environment (MTES). The study includes 2152 students and 1374 teachers from 56 primary (grade 6) and 45 upper secondary schools (grade 12). Multivariate multilevel regression models show that eco-schools' main impact is a decrease in their students' and teachers' utilzation values and amotivation. Adversely, the schools' participation in the eco-schools project also increased both students' and teachers" externally regulated motivation. Differences among schools in student and teacher

outcomes are, furthermore, related to differences in policymaking, didactical approaches to teaching environmentalism and to the presence and educational use of green spaces and green elements at school. Implications for research and practice are discussed.

60. The 2-MEV model and beyond: Towards Quantifying Environmental Citizenship
Franz X. Bogner and Michael Wiseman

A questionnaire battery designed to measure the factors Utilization (U) and Preservation (P) in the field of adolescent environmental perception, since the mid 1990ies, was repeatedly administered to secondary school student populations. Maximum likelihood factor analysis confirmed the both hypothesized orthogonal factors U and P. Both domains construct the 2 factor Model of Environmental Attitudes (2-MEV), following a conven-tion established by Rokeach (1973) employing the term to indicating sets of consistent attitudes. After the first publications, the 2-MEV model of authors (1999, 2006) was repeatedly tested by independent groups confirming the two orthogonal, robust and independent factors of Preservation and Utilization .

Based on Kaiser & Fuhrer (2003), the knowledge model includes (a) knowledge about how the environmental system works and how natural processes operate; (b) knowledge about how to achieve resource conservation and environmental preservation; and (c) knowledge about how best to achieve resource conservation —that is, knowledge about various behaviours' effectiveness in terms of energy savings or reduced carbon dioxide emissions .

Based on a sample of about 1,900 students, we calibrated previously established instruments for ecological behaviour (GEB), environmental knowledge, and attitude toward nature with Rasch-type models. By using path modelling, our theoretically anticipated competence structure revealed a modest behaviour effect on the behaviour set; attitude toward nature turned out to be, as expected, the stronger determinant of behaviour. Overall, we propose a competence model that has the potential to guide us into more evidence-based ways of promoting the overall ecological engagement of individuals.

39. Primary school pupil's conceptions about the excretory system
Rosa Branca Cameira Tracana Pereira, Maria Helena Alves and Graça Simões Carvalho

This study intends to analyse the 5/6 to 8/9 year old pupils' conceptions about the excretory system, before their first formal learning on this topic, one week after teaching and one year after. This transversal study was applied to the four first years of primary school (5/6 up to 8/9 years-old pupils). The sample was composed of 240 students equally balanced among the four grades. The excretory system teaching occurs at grade 3 of the Portuguese curriculum. A questionnaire allowing the use of the technique of expression by drawing was applied and supplemented by verbal expression, both textual and oral .

Several drawing categories about the passage of water and drug, as well as the terms used for the urinary orifice were created out of the pupils' drawings. The results showed two macro-categories: (i) "P (Previous conceptions)", composed of drawings by grades 1 and 2 pupils who had not had formal education about excretion or any other human biology

system; and(ii) composed of drawings by grades 3 and 4 pupils who had had formal education about human systems at grade 3. The analysis of the results showed that the dominant category over the first three years was “continuous tube mouth - urinary orifice”, 93%, 85% and 33% respectively. The categories “two apparatus represented: urinary and digestive” and “three apparatus represented: digestive, circulatory and urinary” had residual values, decreasing from the 3rd to 4th grade .

This study showed that after the formal teaching, a significant conceptual change concerning the anatomy and physiology of the urinary tract occurred, in the sense that previous simple and scientifically incorrect representations were replaced by complete and correct ones .

The results of this study are quite relevant for teachers’ training, especially in initial training, so that teachers can acquire the knowledge about what the alternative/previous pupils’ conceptions about urinary tract are, so that they can use it to improve their teaching and learning process in order to be more efficient in facilitating pupils’ conceptual change in the topic of human excretion.

24. Developing students’ Socioeco Agronomic Reasoning on pesticide reduction
Nadia Cancian and Laurence Simonneaux

Teaching/learning how to reduce pesticide use in productive systems is part of the didactic processing of environmentally socially acute questions (ESAQ). The challenge for teachers is to set up teaching/learning situations which allow students to construct alternatives to pesticides in a shifting context. The knowledge mobilized for this is distributed, situated, plural, some of it stabilized, some of it under construction, even controversial. Based on the work exploring the learning involved in socioscientific reasoning within a sustainability perspective, we propose a method for setting up a problem situation which encourages socioeco agronomic reasoning (SAR): a complex, authentic case study situated on a farm where the farmer is obliged to consider a reduction in pesticides.

To create the problem situation, five blocks of required data have been constructed on 1) the context and stakes, 2) the crop farming method used, 3) the performance of different types of pesticide alternatives, 4) a problematization of the situation to help students make decisions,5) the questions set to help them process the problem.

A didactic strategy is proposed: collaborative work in small groups of students who a priori have different opinions about pesticides with the aim of co-constructing a single reasoned solution the conditions and repercussions of which have to be discussed. We define the criteria and the indicators to assess the quality of the SAR. Two groups of students at the end of their school courses (a vocational agricultural baccalaureate to become farmers and a higher national diploma to become either farmers or farm councilors) have been confronted to the problem situation.

The students’ reasoning was mostly centered on the agro-ecological dimension of the problem, i) those on the vocational baccalaureate course did not generally master the knowledge and procedures needed to co-construct an SAR, ii) certain groups needed to rely

on a personal resource, iii) some students revealed a pronounced techno-scientific rationality, iv) with those on the higher national diploma course, the collective reasoning was more sophisticated v) the students perceived the co-constructed reasoning as more sophisticated in a collaborative set-up. The way the students process the problem situation sheds light on the conditions for the co-construction of situational knowledge and provides the means to discuss the elements which determine the constructions of SARs.

43. The Impact of Environmental Knowledge, Understanding, and Emotions on Environmental Behavior

Nurit Carmi

In the end, we will protect only what we love. We will love only what we understand. We will understand only what we are taught.

Baba Dioum, Senegalese poet and naturalist

This saying inspired educators around the world to believe that teaching environmental knowledge is the key to protecting nature. For many years environmental education has focused mainly on improvement of strategies that enhance the study and understanding of this subject. Current research indicates that environmental knowledge is an essential, but not an exclusive factor of environmental behavior. Our specific objectives were to examine: (a) whether learning (i.e., acquiring environmental knowledge) improves the understanding of environmental issues and problems; (b) whether better understanding of environmental issues arouses emotions or affect toward environmental issues; (c) whether these emotions are translated into action; and (d) the validity of the model expressed in the citation above (knowledge → understanding → affect → behavior). Using a structural equation model allowed us to assess the direct, as well as the indirect, relationships between the four factors (environmental knowledge, understanding, affect, and behavior). The research was conducted with 1114 undergraduate students enrolled in different disciplines of study. We adapted a series of environmental knowledge questionnaires used in previous studies for the specific purposes of this research. The respondents were also asked to rate the degree to which they felt they understood environmental problems and their solutions, their feelings towards different behaviors that damage or benefit the environment, and, finally, to report the extent to which they practiced different environmental behaviors.

Emotion emerged as the only strong, significant direct predictor of environmental behavior. Knowledge and understanding did not contribute directly, but their indirect contribution, with emotion as the mediator, was significant. These findings indicate that knowledge is an important but distal variable, compared with emotion, and that both are essential components in producing environmental behavior. The model explained 91% of the variance in environmental behavior, its fit measures supported its hypothesized structure and validated the saying quoted above. These findings may contribute to the understanding of the process of converting environmental knowledge into understanding, emotional involvement, and behavioral action. The theoretical and practical implications for creating pro-environmental attitudes, concern and behavioral change will be discussed.

141. Meet the Scientist: scientist-student interactions as part of an initiative to promote health and science literacy through science education

Andri Christodoulou, Kathryn Woods-Townsend, Jenny Byrne, Marcus Grace, Janice Griffiths and Willeke Rietdijk

The purpose of this study was to explore the value of student-scientist interactions in the context of a wider project that aims to promote health literacy through a focus on epigenetics and how the decisions that adolescents make about their health influence not only them, but also their future health and the health of their children. For that reason, 20 biologists/researchers were asked to each share their experiences of becoming and being a scientist in short 20-minute sessions, with groups of 7-8 students. The student sample consisted of 180 Year 9 students (14-15 years old) and 43 Year 8 students (13-14 years old). Student questionnaires were used before and after the 'Meet the Scientist' sessions to assess students' views of scientists and their science career aspirations. The face-to-face interactions with scientists, allowed students to view scientists as approachable and normal people, and to begin to understand the range of scientific areas and careers that exist, beyond the traditional doctor and 'science' teacher professions.

8. Junior high school science and technology teachers' attitudes regarding mentors and mentor contribution to the assimilation of curricular changes

Rachel Cohen and Fatin Azar

The science and technology (S&T) curriculum in Israel was changed in 2009. According to Hudson (2007), school mentoring may influence teachers' practices in science education reform. Thus, school mentors were appointed to implement curriculum changes. The purpose of this study was to examine S&T teachers' attitudes with regard to mentor characteristics and mentor contribution to the assimilation of curriculum changes. We examined 59 junior high school S&T teachers' attitudes towards a defined five factors mentoring model (i.e., personal attributes, system requirements, pedagogical knowledge, modeling, and feedback) (Hudson & Skamp, 2003). We also studied teachers' attitudes towards mentors' contribution to the assimilation of curriculum changes. Data was collected using a quantitative questionnaire that included 47 statements (Cronbach alpha 0.8). Positive attitudes ranging from 2.96 to 4.11 on a scale from 1-5 were found regarding all the factors of the attitudes. However, it seems that mentoring professional development programs should train mentors on feedback (e.g., provide oral and written feedback on lesson plans and teacher teaching).

46. Towards Education for Sustainability in an Arab School in Israel - A Case Study

Lilian Daniel and Tali Tal

In this study we follow the process of transforming an Arab school in Israel into an environmentally oriented school, while focusing on eighth grade students and their teachers for two years. We believe that since the school's staff is involved in the process of developing and adjusting the education for sustainability (EfS) program to the students, and

also by having the students learn and debate about their local and global environment while using socio-scientific issues, the awareness of the students and teachers towards the complex relations between society and the environment evolves .
The research questions were :
1.What are the characteristics of the EfS program in the Galilee school ?
2.How do students, teachers and staff view the EfS program ?
3.What is the students' performance in socio-scientific issues tasks by means of: (a) identifying the problem/conflict; (b) identifying stakeholders and different positions; (c) performing value judgment; (d) making reasoned decisions; and (e) system thinking ?
Semi-structured interviews were conducted with ten students and six teachers and administrators, and socio-scientific tasks were developed and administered to the entire class. In addition, class and school activities were observed and documented. We found that the students, teachers and administrators viewed the action component of the EfS program most significant while highlighting the project-based and place-based learning and the outdoor activities. The use of socio-scientific issues in EfS programs was found to be useful by means of increasing the interest and engagement of students in classroom discussion. The socio-scientific tasks indicated improvement in the students' performances that was retained after the program has ended. The students stated, throughout the program, that the local residents and their norms and actions contributed to the deterioration of the local environment while reflecting some understanding of the complex socio-environmental issues. The findings indicate the engagement of the teachers and students in mutual design of the EfS programs helped in meeting the needs of the target population. The EfS program was successful in altering the traditional teaching methods practiced in the Arab schools in Israel towards more active and learner-centered. We argue that in order to promote a more sustainable-culture within the school, there is a need for the school to promote a more sustainable agenda in teachers' work and practices, hoping that this will encourage better collaboration between the teachers.

65. Techno-moral-vignettes: A useful tool to introduce synthetic biology related socio-scientific issues

Chantal de Ruijter, Marie-Christine Knippels and Arend Jan Waarlo

Synthetic biology (SynBio) is a new high-profile area of research in biology that develops rapidly and entails both promises and perils. At the moment, we are therefore on the threshold of social discussions about SynBio related socio-scientific issues (SSIs). To be able to form opinions and make informed decisions about SSIs generated by new developments in biological research, students need to be prepared. A possible way of introducing those issues is by use of future scenarios. The present study investigated the educational potential of techno-moral vignettes for introducing SynBio related SSIs. Techno-moral vignettes are short stories, informed by recent scientific publications, in which possible future applications and moral dilemmas are being introduced. They can be a helpful tool in imagining SynBio-related futures and starting up SSI-based learning process in secondary

biology education. To probe the educational potential of those vignettes, ten upper secondary school students (five males and five females) from the fifth grade of pre-university level (average age 16.3 years), were interviewed in individual face-to-face interviews and subsequently in two gender-mixed focus groups. The students were asked to read a vignette and react upon the story described. Five vignettes were used in total. The results demonstrate that techno-moral vignettes have educational potential because they evoked some emotions and a broad range of normative and factual questions, values and reasoning types in the students. Those aspects are important to develop knowledge on SynBio and to work on citizenship education. The vignettes used covered different parts of the broad range of questions, values and reasoning types. Therefore it is advised to use two or more vignettes for the development of an educational strategy and to test this strategy in a larger setting.

63. Exploring Nature and Biodiversity: Intervention of a residential week-long field course with adolescents attitudes knowledge and behavior

Olivia Dieser and Franz X. Bogner

Intensive educational efforts towards conservation and biodiversity protection already produced an increasing awareness in our today's society. Nevertheless, school students still are essential educational targets within this context. Previous studies showed outdoor nature experience to substantially support adolescents' positive attitudes as well as behaviour and promote their environmental knowledge as well. Within our outdoor ecology programme in a National Park, we monitored environmental behaviour, attitudes towards conservation and knowledge levels as well. Strong emphasis was put on valuing nature and species conservation as well as on the characteristics of the national park's forest ecology. These issues were mainly experienced outdoors, for instance, as simulation role plays (e.g. "storage strategies of squirrels") by specifically elucidating the connection of nature with humans and other species. In a quasi-experimental design, we analysed three treatment options regarding the knowledge impact, connectedness to nature and empathy to animals. Additionally, individual associations were collected to monitor preferences concerning forest, wolves and lynxes .

A sample of 4th and 5th graders (n=391) experienced a week-long programme with three follow-up options. The first option engaged 143 pupils with thematic posters of the programme content, in the second one, 138 pupils additionally completed a thematic board game, and, in the last one (n=88), both these options were dropped. Initial impact analyses regarding the students' knowledge indicate its significant increase directly after the programme and, as expected, a slight decrease six weeks later. Interestingly, subsamples of high pre-knowledge scores showed a decrease just after and again a small increase six weeks after the implementation. Reasons for these unexpected results are under analysis. Further analyses focus on gender and school backgrounds. Detailed results will be presented and discussed at the conference.

106. Are students' conceptions about environmental topics changing? A comparative study between 1995 and 2013 of students' previous ideas about water cycle

Jose Ramon Diez, Jaume Ametler and Sukarrieta Taldea

Students' conceptions become a key part of science education as part of the contructivist educational perspective. A miriad of studies on a variety of science topics, have provided a corpus of known students' previous ideas. These studies have been conducted all over the world and, by and large, have shown great regularity across national contexts. However, much less attention has been paid to whether these alternative conceptions remain the same across cohorts of students from different years .

During the past 18 years our planet has undergone an important environmental transformation. The increase of human population and the per capita use of natural resources is such that the ensued environmental change has a global dimension and is affecting all of Earth´s ecosystems. In parallel with this transformation society's level of awareness about the related problems has risen and the schools have done a considerable effort on this line. Thereby, environmental education and sustainability education programmes have multiplied over the last few years. This situation underpins the main hypothesis on this study, mainly that there might have been an evolution on the students' conceptions around environmental issues .

To test our hypothesis we have compared data about students´ conceptions from 1995 and 2013 about environmental issues collected at a nature discovery centre, (Centro de Experimentación Escolar de Pedernales (CEEP/ Sukarrietako Eskola Saiakuntzarako Zentroa/ Pedernales's Centre of School Experimentation), which is the reference environmental education centre for schools in Bizkaia, the most populated region o the Basque Country. Since 1995 the centre has been collecting data of students' ideas through the use of worksheets including written questions and drawings. Students' responses collected from 1665 during the 1994/1995 academic year were analysed and published (Gutiérrez-Bastida, 1998) providing insights on the different ideas and their level of complexity for students of different ages. The fact that the same instruments are still used has allowed us to compare the results of 1995 with those obtained from 2441 students during the 2012/2013 academic year. Initial results suggest that there are changes on the students' conceptions which will be of interest to teachers and educational material designers on the fields of environmental and sustainability education.

Keynote speaker: Reasoning in genetics: concepts, practices, and a learning progression

Ravit Golan Duncan

Over the past decade there has been a tremendous influx of research and technological advances in genetics into the public domain. The availability of genetic testing, prevalence of genetically modified organisms, and ongoing debates about their use place increased demands for genetics literacy on the public. However, learning genetics is fraught with challenges and high school graduates, in many of countries, lack fundamental understandings in genetics. Reasons for these difficulties include misguided assumptions

about the developmental readiness of students to learn particular concepts in genetics, and a fragmented and incoherent curriculum for teaching these ideas. Recent reform efforts in the U.S. advocate for sequencing the curriculum according to research-based learning progressions, which are developmental models that describe successively more sophisticated ways of reasoning in a domain. My research over the past decade has focused on learning progressions in genetics and how we can use them to develop instruction to support deeper and more meaningful understandings of core ideas in genetics. I will discuss our efforts in developing assessments and instructional activities that are linked to the genetics learning progression, and present preliminary findings from an implementation study using these materials and assessments in biology classrooms.

145. Novel extracurricular settings: How do pupils handle lack or provision of structure.
Alexander Eckes and Matthias Wilde

Teachers visiting extracurricular settings face the challenge to organize the field trip. This raises the question: Is imposing structure on an out-of-school setting necessary? According to Falk and Dierking (1978) the novelty of a setting influences the actions of visitors to a great degree. High novelty might lead to anxiety and hinders pupils engaging with exhibits or working materials. To support motivation, structure and autonomy supportive behavior are vital (Skinner, Furrer, Marchand & Kindermann, 2008). This study was carried out with 223 5th and 6th grade pupils who visited an extracurricular setting for a period of four hours in which they took part in an exhibition thematically centered on the locomotor system of different animals. Both, experimental and control group were treated autonomy supportive. The experimental group received additional structure in form of pre-visit preparations, structure supportive instructions, explanations of working materials and their usage .

The research focused upon the provision of structure to reduce novelty and improve pupils´ engagement. Results suggest that pupils provided with structure handle exhibits with more ease, were less dependent on help and support from tutors working more self-reliantly and self-regulated.

153. Enhancing students' socioscientific decision making in the biology classroom: the influence of cooperative learning environments
Sabina Eggert and Susanne Bögeholz

The implementation of socioscientific issues within the science classroom has been identified among science educators and curriculum developers as one core element in order to support students becoming informed citizens (e.g. AAAS 1989; NRC, 1996; Ratcliffe & Grace, 2003; Sadler, Barab, & Scott, 2007). Socioscientific reasoning and decision making comprises several elements such as the ability to search and evaluate relevant information, the ability to argue and reason about possible solutions strategies or the ability to reflect on decisions processes, including inherent values and norms. Thus, evaluation and monitoring processes play an important role .

In the present study, we examined the effect of two cooperative learning environments on students' socioscientific reasoning and decision making. Group one worked in a cooperative learning environment (COOP), while group two worked in a cooperative learning environment with an additional embedded metacognitive training (COOP META). We used a quasi-experimental pre-posttest design .
Data analysis was conducted using probabilistic as well as classical test theory and addressed two main questions: the aspect of measuring invariance as well as the differential effects of both treatment groups. Results showed that partial invariance was ensured. A repeated measures ANOVA showed main results for measurement point in time as well as treatment. However, no interaction effect could be found. Implications concerning the measurement procedure as well as optimization of both treatment group designs are discussed.

71. Teaching systems thinking: Evaluating an intervention for biology and geography students (Symposium: Systems Thinking)

Daniela Fanta, Julia Braeutigam, Werner Riess and Stephan Schuler

The fostering of systems thinking is an often posed demand in education for sustainable development (ESD) which is only rarely put into practice. Several studies have shown that systems thinking can be fostered in students of all education levels, such as Sommer et al. (2010) and Riess and Mischo (2010).
However, currently systems thinking is not included in the education of teachers, neither at the level of individual competence nor at the level of PCK (pedagogical content knowledge). Furthermore there are still no proven measuring instruments available to examine the construct of "systems thinking" and the related PCK skills (Pedagogical content knowledge to promote systems thinking in lessons).
Within our research project a test was developed on the basis of a heuristic competence model in order to measure systems thinking. The test was applied to evaluate three newly created courses for fostering systems thinking for biology and geography students .
In a quasi-experimental intervention study in a pre/post follow-up test control group design the effects of the courses were examined .
After the completion of the courses, the results of all student test groups were shown to be significantly higher than at the beginning. Compared to the control group there was a high effect of fostering systems thinking in the experimental groups.

126. Understanding of nature, sustainability and ESD by prospective Biology teachers

Katja Feigenspan

Nowadays an important interdisciplinary concern of Biology education is Education for Sustainable Development (ESD). Sustainable development is an integral and integrative approach uniting an ecological, an economic and a social dimension, and ESD pursues the goal to capacitate young adults to shape the future having regard to those three dimensions .

Various (mostly quantitative) studies show that the explicit knowledge in terms of sustainability and ESD is fragmentary and that a one-dimensional ecological view is dominating. Studies concerning child and youth understanding of nature and sustainability bare a very infantile, romantic and naive view. As ESD is one of the main challenges for the future teacher generation, obviously qualitative studies especially of this target group are lacking to concrete their ideas of nature and sustainability .
The aim of this qualitative interview study is to see into the implied ideas of biology student teachers concerning nature, sustainability and ESD, to see into their ideas of teaching and imparting ESD as well as their ideas of the aims of Biology education concerning "nature". Therefore 10 semi-structured interviews with prospective Biology teachers based upon an interview guideline and using various stimuli were conducted and a system of categories was developed using the qualitative content analysis according to Mayring with the help of MAXQDA10 .
Four different types of understanding sustainability could be identified and characterized. They span the view that sustainability is similar to leaving nature untouched up to the concept that sustainability means to minimize damage to humans and they all stick together with the personal understanding of nature and the perspective on the relation between humans and nature. Conceptions about teaching and imparting ESD however are mainly influenced by traditional environmental education and partly lack solid understanding of ESD.

32. Assessing the value of curricular coherence for the instruction of energy (Symposium: Energy)

David Fortus

Current attempts to improve science learning highlight the importance of cross-cutting concepts such as systems, structure and function, stability and change, while also emphasizing the importance of disciplinary core ideas. The concept of energy transformation, transfer and conservation, its interactions with matter, is both a cross-cutting concept and a disciplinary core idea in almost every scientific discipline. Physicists rely on energy conservation when trying to understand how sub-atomic particles obtain their mass. Biologists use energy to describe the relationships within ecosystems. Geologists use the principle of energy conservation to understand earthquakes. Energy is truly one of the most fundamental and far reaching of all scientific concepts. It's therefore not surprising that energy is a central cross-cutting concept in many nations' science education standards. Despite its importance, few instructional strategies have been shown to foster the development of an integrated understanding of the energy concept .
One of the major problems that have been identified with regards to energy instruction is the incoherence of most curricula. Curricular coherence is an indication of the alignment of content ideas, the depth at which they are studied, language, and the sequencing of ideas within and across grade levels and has been identified as an important predictor of student performance. In traditional curricula, ideas learned in biology do not build off ideas taught

in physics or chemistry and vice-versa. For example, physicists speak of the transformation of energy between multiple different forms but the conservation of the sum of all the forms, while biologists might use the Gibbs energy (a non-conserved function) to determine the direction of change in biological systems and to understand how coupled reactions can drive thermodynamically unfavorable processes. Both speak of energy but what is the connection between them? Why is energy conserved in physics but not in biology? What are students to think of energy after all this ?

This study used SEM to examine the contribution of coordinating language and sequencing topics related to energy across middle school to supporting the construction of an integrated understanding of energy. Results indicate that the curricular coherence allowed the knowledge constructed in one unit to become the prior knowledge to be built upon in subsequent units and enabled students to develop a deeper understanding of energy

119. The effects of an intervention program using biology metaphors on hemispheric processing

Tsipi Franko and Nira Mashal

This study aims to explore hemispheric processing of biology metaphors in high school students. According to Bowdle and Gentner's "Career of Metaphors" theory (2005), novel metaphors are comprehended via a comparison process, whereas conventional metaphors are comprehended through categorization. Thus, novel metaphors are perceived like similes (A is like B), while conventional metaphors are perceived as categorical assertions or metaphors (A is B). Based on this theory, an intervention program to enhance comprehension of metaphors of genetics utilizing biology metaphors in high school students was developed .

This study aims to 1) Test whether conventional biology metaphors are better understood via comparison processes as opposed to the comprehension of novel metaphors via categorization. 2) Test differences in hemisphere involvement in processing biology metaphors with different conventionality levels. 3) Examine the influence of biology metaphor intervention on high school students' motivation and misconceptions in biology lessons .

80high school biology students were divided into: a. an experiment group subjected to an intervention program utilizing metaphors for genetics for comprehension of biology; b. a control group. The intervention program was based on the "Teaching with Analogies" (TWA) model (Glynn, 2008). Behavioral visual field experiments was employed to examine hemispheric lateralization during the processing of studied vs. non-studied metaphors (Mashal & Faust, 2009). Questionnaires were used to test motivation for, and comprehension of, science studies, as well as misconceptions of genetics .

The results show faster reaction times for conventional metaphoric sentences (A is B) in the left hemisphere as compared to the right hemisphere, and faster reaction times for novel sentences (A is like B) in the right hemisphere as compared with the left hemisphere in the experiment group as compared with the control group. The results indicate that new

metaphors for science are better understood in simile form, i.e. via a comparison process. The results of a quantitative content analysis of the subjects' answers in the Motivation Questionnaire show significant differences between the two groups: subjects in the experiment group who learned biology metaphors according to the TWA model showed increased interest in and motivation to study science without an increase in misconceptions .
Our results indicate that the application of the TWA model in teaching metaphors does not induce misconceptions in genetics. In addition, motivation for learning science can be increased. The results also point, for the first time, to the differential involvement of the two cerebral processes in understanding science metaphors.

103. Concerns of experienced Biology teachers
Yael Furman Shaharabani and Anat Yarden
Experienced teachers have knowledge of their students' difficulties, based on their own practical experience. Nevertheless, professional development programs tend to focus on subjects selected by supervisors or by educational researchers, while teachers are seldom asked about their preferences regarding their own professional development. Thus, knowledge of teachers concerns may contribute to decision making about the focus of professional development programs for in service biology teachers. In this study we explore the concerns of experienced biology teachers regarding their teaching, as manifested in their choices while conducting action research projects, in the course of a M.Sc. program. Specifically we asked: what are experienced biology teachers' concerns regarding their teaching as reflected in their choice of topics for action research and in the reasons they raise for their own choices? Thirty six experienced biology teachers who participated in four sequential courses during 2009-2013 participated in this qualitative study. The data sources were: teachers' research reports, learning diaries and reflections, classes' audio recordings and on-line discussions. The biology teachers' main concerns as reflected in the subjects they chose for their action research projects were enhancing students' understanding and developing students' skills. The reasons for choosing a topic were related to either specific experience or observation or to general issues of teaching and learning improvement. The teachers selected subjects which they consider to be important to biology learning. The teachers' practical knowledge of their students' difficulties is a necessary starting point in the way of improving teaching and learning biology. The concerns of experienced teacher, as presented in this study, reflect real problems and can serve as starting points of professional development programs and research.

81. Croatian students interest in health-related topics
Diana Garasic, Ines Radanovic and Zaklin Luksa
In curriculum creation it is important to know students' interests, especially having in mind increasing teachers' complaints about students' lack of interest and learning motivation. Health-related topics generally are appealing to students, but their preferences change

regarding content and with age and gender. In order to identify these differences, ROSE questionnaire was used in transversal survey on Croatian student population age 11-18. The results analysed for each of 26 questions yielded an overall average evaluation of interest, average evaluation per age group, and average evaluation per gender. The highest scored topics are those which are potentially the most influential in the adolescent life. The interest in the majority of topics was the highest with the youngest respondents, the lowest with the 14-year-olds and again higher with the students of gymnasia. Overall, girls are more interested in health-related topics, but boys are more interested in the issues related to epidemics and diseases that cause large losses of life. The largest gender differences appeared for the topics related to various cosmetic procedures, birth control, abortion and pre-natal development. Interest in sex and reproduction is greater among boys younger and girls older than 16. Broadening the gymnasia students' general knowledge increases the appeal of topics such as causes and treatments of serious illnesses and the application of gene technology in their prevention. The identified pattern of adolescents' interest, focused on the topics which potentially or directly have influence on them, can be used for motivating their learning and defining the focus of curricular topics.

151. The potential of text from scientific vulgarization magazines for the innovation of genetics approaches in school context

Tania Goldbach, Marisa Costa Gomes, William Alves Pereira, Laion Victor Oliveira Okuda and Beatriz Dos Anjos F.S. Da Silva

The use of scientific vulgarization magazines (SVM), as a tool to support school practice, has been identified, in the Brazilian educational scenario, as one of several strategies that favor the building of a contextualized way of looking at scientific subjects. This study has as its main goal to identify the articles/reports/notes related to the theme 'genetics' in the SVM, specially in the brazilian magazine "Ciência Hoje" and to indicate the approaches and the characteristics in that articles/reports/notes which can reveal their potential as educational tools for the development of a meaningful insight about the theme. The literature on research in Biology Education notes many problems in the way the teaching of genetics is going, those point some challenges to be faced which the present research. Our methodology is anchored in textual analysis of items in the magazine "Ciência Hoje", from April/2012 to Abril/2013, in an attempt to recognize the three aspects considered problematic in the research context of Genetics Teaching (Integrating Approaches, Contextualization and Updating). We selected 24 articles/reports/notes and there were registered: their location and references in the magazine, the author/researcher or journalist when presented, sub- theme addressed and the presence of any of the three aspects analyzed. Preliminary analyzes indicate that the texts provides potential material to be reframed for educational purposes, either directly by the teacher or in planned and organized activities for students , according to the different realities of teaching. The results indicate the presence of sub - themes that favor integration (12), contextualization (13) and updating (11) of issues related to genetics. The texts vary in complexity and depth, as well

as in more or less association to daily life and issues involving the relationship among STC. We believe that the results announce and reinforce the role of the STC as one of teaching resources which are intended to foster and promote the construction of knowledge in the classroom. This work is in progress with research in other SVM. We hope that our investigations will help to light the pathway diversified of building - in the community of teachers, teacher educators and researchers - one "school genetic", that recognizes the different elements and processes linked inheritance - transmission and expression of the characteristics as well as study technologies and associated applications - enhancing the role of the genetic material, but understanding that it is part of living systems where complex webs and networks of regulation and modulation are present.

55. Improving classroom-based decision-making about obesity as a socio-scientific issue
Marcus Grace, Andri Christodoulou, Kathryn Woods-Townsend, Janice Griffiths and Jenny Byrne

Non-communicable diseases (NCDs) account for almost two thirds of deaths globally, and yet 80% of these deaths could be prevented through changes in lifestyle. Obesity is a major risk factor associated with NCDs. This study shows the impact of a pedagogical approach to adolescent decision-making in relation to obesity by exploring the values and biological understanding among 14-15 year olds. Qualitative pre and post-testing of health-related attitudes, and analysis of peer-group discussion using a structured decision-making framework is demonstrating that this approach helps improve the quality of reasoning about being overweight and obesity. It also highlights adolescents' lack of knowledge about the implications of obesity in relation to NCDs, and they draw on a very limited number of biological concepts in their discussions. However, discussions lead most students to a modified solution to the issue and a broader range of suggested solutions. The study also begins to reveal features about students, as individuals and as members of discussion groups, which promote values considerations and decision-making skills, and which teachers can realistically identify, nurture and evaluate. Cultivating these features and appropriately integrating them with learning about biological concepts that underpin health issues will facilitate the development of teaching strategies for dealing effectively with controversial issues such as these; not only in relation to content and concepts, but also in terms of how students are expected to engage with the issues as citizens.

26. Biology Teachers' Content-Related Knowledge: Structure and Learning Opportunities
Jörg Großschedl, Daniela Mahler, Ute Harms and Thilo Kleickmann

Teachers' content-related knowledge is a key factor influencing the learning progress of students. Different models of content-related knowledge have been proposed by educational researchers. Thereby, content knowledge (CK), pedagogical content knowledge (PCK), and curricular knowledge (CuK) have been distinguished. As there is no consensus about the empirical structure of content-related knowledge in biology yet, a total of 134 biology teachers completed tests which were to capture the hypothesized components. The

empirical structure of content-related knowledge was analyzed by multi-dimensional Rasch analysis, which suggests content-related knowledge to be composed of CK, PCK, and CuK. PCK and CuK are highly related (r latent=.70). The latent correlations between CK and PCK (r latent=.48) - and CuK respectively (r latent = .35) - are moderate to low (all ps < .05). Beyond the empirical structure of content-related knowledge, formal ([a] type of teacher education program, [b] professional development in workshops and lectures) and more informal ([c] teaching experience) learning opportunities for biology teachers were investigated with regard to their relationship to CK, PCK, and CuK. Our results show that in-depth training and attendance to professional development courses are positively related to PCK. Moreover, in-depth pre-service training was related to teachers' levels of CuK, and attendance to professional development courses correlated positively with CK. Finally, our results show that teaching experience is negatively related to CuK, but not with CK and PCK. Our results suggest that formal learning opportunities during the pre-service and the in-service phase may positively impact the development of content-related knowledge. However, the more informal learning opportunities as operationalized through the years of teaching experience seem to be not as relevant.

96. Effectiveness of an Environmental Education Program in Promoting Sustainable Consumption

Demetra Hadjichambi, Yiannis Georgiou, Andreas Hadjichambis, Hara Ioannou and Constantinos Manoli

During the last decades, consumerism and current consumption patterns have been recurrently blamed for rendering both the environment and our lives unsustainable. Young people are considered a critical group in the effort to make a shift towards sustainable consumption. However, these future citizens, in most of the cases, seem to be generally uneducated, since their current consumption patterns are not-sustainable. In this context, Environmental Education Programs are considered as a venue of paramount importance for introducing issues of sustainable consumption within the learning procedure. Taking into account, the general lack of studies focusing on the evaluation of EEPs promoting sustainable consumption, the present study investigates the effectiveness of an Environmental Education Program (EEP) in young people aged 8-12, in order to become more sustainable and green consumers,. The one-day EEP "Sustainable Consumption, 4R" was applied to 286 students (130 boys and 156 girls), from five suburban elementary schools and data were collected through a word association procedure as well as through a decision-making open-ended written test, following a pre-post research design. The analysis of the data revealed that the EEP employed, helped young learners to change their representations into more sustainable ones and provided young people with more environmental criteria, allowing them to take more environmental-friendly decisions as consumers. At the same time, analysis of the data shed some light on the correlations between students' representations and their decision-making process, providing an

empirical documentation for the interplay between students' conceptualizations and students' decision-making criteria.

133. Human reproduction – An Inquiry based biology module: 7th-graders students' conceptual understanding, motivation and help-seeking

Andreas Hadjichambis, Yiannis Georgiou, Demetra Hadjichambi, Kyza Eleni, and Demetrios Mappouras

Human reproduction is a major socio-scientific issue; however studies focusing on the development and evaluation of inquiry-based learning interventions promoting the knowledge of human reproduction are very few. The aim of the present study is to evaluate the effects of an inquiry-based intervention on human reproduction on students' conceptual understanding, motivation and help-seeking. The inquiry-based learning module was designed and implemented in all 7th graders in Cyprus. The research was coordinated by the Ministry of Education and Culture. Data collected included students' pre- and post-tests to assess conceptual understanding regarding human reproduction and measurements of student motivation as a result of their engagement with the inquiry module. The sample for the pre- and post-test data included 6465 students. Students' motivation data were collected through the MOLE motivation survey administered to a representative sample of the entire 7th grade dataset (n=945 students). Statistical comparisons indicated a statistically significant increase in students' conceptual understanding as well as in students' motivation when compared with students' motivation in previous, non-inquiry biology modules. Our results also point out statistically significant gender differences, both on learning gains as well as on motivation. Girls exhibited higher initial and final level of knowledge than boys and were also more motivated, indicating that boys need increased support. Analyses revealed significant correlations between students' learning gains and motivation and suggest that, as expected, motivation and conceptual understanding are intertwined; subsequently both factors worth adequate attention in designing learning material. A comparison between an ExplicitScaffolding inquiry based learning environment and an ImplicitScaffolding inquiry based learning environment was enacted. The ExplicitScaffolding inquiry based learning environment relied on the teacher, peer collaboration, and worksheets to support the learning process. The second context involved a less-structured inquiry environment (ImplicitScaffolding), in which students collaborated to address the same problem; students relied on a scaffolded web-based inquiry investigation, peer collaboration and the teacher for guidance. According to the results the ExplicitScaffolding pair directly sought the "right answer" (executive help) more often, whereas their help-seeking was focused on domain knowledge. The ImplicitScaffolding pair sought help less often and this help was coded as instrumental or procedural. These findings highlight the connections between collaboration inquiry scripts, students' conceptual understanding, motivation and scaffolding and bear implications about the design of learning environments to support self-regulated inquiry.

30. Learning about Energy at Primary Level: Biological contexts as a starting point for energy learning? (Symposium Energy)

Ute Harms, Sebastian Opitz and Knut Neumann

Energy has been introduced as a core idea and cross-cutting (interdisciplinary) concept in the curricula or national science standards of different countries in order to ameliorate more cumulative learning. Little research has so far been done to study the conceptions of energy in biological contexts (Jin & Anderson 2012). With contexts like nutrition, health, energy sources or movement, numerous biological contexts with either implicit or explicit relevance for energy learning can be identified in young learners' science / biology text books and curricula. We assumed several learning opportunities about energy to exist in biological contexts before the beginning of more formal, explicit physics instruction on energy .

To investigate a possible development of energy concepts as a consequence of the above-mentioned learning opportunities, we conducted an explorative, cross-sectional questionnaire study with N=539 German students at the end of grades 3 to 6. Multiple-choice questions were constructed along a two-dimensional structural-development model for energy understanding, originating from physics education research (Neumann et al. 2013), focusing on four central energy aspects (forms, transfer / transformation, degradation / dissipation, conservation). Cognitive abilities, motivation / interest in science education and reading ability were assessed as control variables .

Results showed a significant development of energy concepts in both test versions, indicating a strong effect size of ω= .39 / .15 respectively. For energy conservation and degradation, students' results were more limited than for energy forms and energy transfer, reflecting a focus on these aspects in school books, curricular and teacher statements on their teaching practice. Results from multiple regression analysis (R^2=.345; corr. R^2=0.341) showed a major effect of grade level, followed by reading skills and only to a smaller degree, cognitive skills. The results indicate that young learners not only can learn about abstract concepts such as energy (Shultz & Coddington 1981; Novak 2005), but that they also do so in learning opportunities of everyday school life – specifically in biological contexts. The findings underline the importance of a more detailed coordination of interdisciplinary energy learning, enabling students to use energy as a 'key' to analyze abstract contexts with in different disciplinary contexts. In biological contexts, this ability may be limited (at least in lower grades) due to the students' limitation of energy understanding to mostly energy forms and transfers / transformations.

21. How to evaluate visualizations on evolution? An initial analysis using a criteria catalogue including threshold concepts

Jennifer Härting, Gustav Bohlin, Ute Harms, Anja Nordbruch, Daniel Orraryd and Lena Tibell

There is a huge body of literature in biology education research showing that the central biological concept of evolution is a very difficult topic to understand and to teach. A

proposed reason for these difficulties is that evolution subsumes many different abstract and so called threshold concepts, e.g. randomness or probability. Research on visualizations (videos, animations, and simulations) as tools for supporting understanding has shown that these media can promote learning if certain design features are considered. In our bi-national project "Challenging Threshold Concepts in Life Science – enhancing understanding of evolution by visualization" (EvoVis) we bring these two research branches together. Thus, the overarching hypothesis of our project is that visualizations that succeed in illustrating the respective threshold concepts can support the understanding of evolution. Here, we want to present the first study of our EvoVis project focusing on an analytical tool developed as a first step .

Before asking what and why you can learn by visualizations on evolution our question in the first study was, what kind of visualizations on evolution are available for everybody on the Internet and what quality do these have. To assess the quality an analytical criteria catalogue for animations was developed stressing threshold concepts relevant for evolution: randomness, probability, complexity, temporal and spatial scale. 110 english-speaking animations, simulations and videos out of a vast number of respective visualizations detected in the internet were selected and put in a database. By means of the criteria catalogue a sample of 36 were analyzed in parallel by at least three project members. The results show that there are a lot of different kinds of visualization types on evolution on the internet. These can be quality ranked by our catalogue. Also our analysis shows high differences concerning the quality of visualising threshold concepts of evolution. From the analysis results quality categories for visualizations on evolution were derived.

7. Teaching competencies in experimental lessons – Modeling and development of a test instrument

Sascha Hasse and Marcus Hammann

This dissertation project aims at the theoretical foundation, empirical verification and validation of a competence model for teaching competencies of biology teacher trainees in experimental lessons as well as the development of an associated reliable and valid test instrument. The focus lies on "analyzing experimental biology lessons" and "planning experimental biology lessons" for grade five to ten.

A range of different frameworks and models have been combined to provide a theoretical background for the competence model. The competence model is based, in particular, on normative standards and frameworks of teacher competencies in higher education, PCK models, the SDDS model (Klahr 2000), and national and international subject didactic findings on scientific experimentation in the biology classroom.

The new test consists of context-based and content-specific test items. They confront teacher trainees with realistic descriptions of classroom scenarios and student achievement .

For item development, a competence model specifying dimensions and levels of students' competencies in biological experimentation (Hammann 2004; Hammann, Phan & Bayrhuber 2008) was used. Teacher trainees are required to plan and analyze lessons that focus on fostering the students' competencies of forming hypotheses, planning experiments and analyzing data .

The approach to item development is interesting to research on PCK beyond the specific field of PCK related to experimental biology classes, as items require teacher trainees to make informed decision about teaching goals, methods and described in the teaching scenarios. Item development and item revision is an iterative process (Wilson 2005), with think-aloud protocols used for testing hypotheses and refining theoretical assumptions .

Item frameworks and prototypical test-items have already been developed and tested with think aloud protocols (n = 15). The think-aloud protocols are presently being used for revising and optimizing test items. Expert ratings will further contribute to evaluate the model and the items .

The main study, planned for 2014, is going to involve 500 biology teacher trainees. The sample will be drawn from students at the universities of Münster, Göttingen und Bamberg. Data will be used for one-dimensional and multidimensional modeling .

The poster gives insight into the development of the competence model for teacher trainees. It also describes the specific way of testing the analyzing and planning competencies and shows two of the test items. Moreover the findings of the think aloud study will be presented.

137. Influence of teaches behavior on pupils' motivation

Natalia Hofferber and Matthias Wilde

Weinert (2002) distinguishes between conceptual and procedural competences as well as performance competencies. Amongst others pupils need 'motivational competencies'. During school life, the motivation of pupils decreases (Wild, Hofer & Pekrun, 2006). One reason for this could be the controlling teacher behavior in class (Martinek, 2010). According to self-determination theory (SDT) controlling teacher behavior undermines pupils' positive motivational quality (Deci & Ryan, 2002). SDT postulates three innate psychological needs for every human being: the need for relatedness, competence and autonomy. The experience of autonomy is a key factor for experiencing intrinsic motivation (Schiefele & Köller, 2006). Csikszentmihyi (1997) termed intrinsic motivated activities as "autotelic"; these activities are done because they are immediately rewarded by themselves. If a person is fully involved in the process of an activity, he or she might be in a perfect flow state. Both, Flow Theory and the SDT refer to intrinsic motivation and are complementary to each other (Schiefele & Köller, 2006). The Flow Theory addresses the positive conditions during an intrinsically motivated action (Csikszentmihyi, 1997). The SDT describes the innate psychological needs of human beings to be intrinsically motivated (Deci & Ryan, 2002).

At present, no studies exist that explore controlling vs. autonomy supportive behavior in regular biology classes in respect of intrinsic motivation. Our study examines the effect of an autonomy supportive teaching style in biology classes on pupils' intrinsic motivation and flow experience .
On this basis, a three- hour teaching unit on the issue of Eurasian Harvest Mice (Micromys minutes) was executed in four biology courses (N=95; age: 12.85 1.6) of the 7th grade. Two classes served as the experimental group A treatment, in which teachers acted autonomy supportively (and the order of the tasks to be processed and the group members were chosen by the pupils) and two classes as control group C treatment, in which teachers acted controllingly (and the order of the tasks was determined and the group members were chosen by the teacher).
We found that the A treatment had a significantly higher flow experience than C treatment. Moreover, after one week of the teaching unit, there was a highly significant motivational difference between A and C treatment.

129. Addressing the social dimension in the study of biological socio-scientific issues
Tasos Hovardas and Konstantinos Korfiatis
Biological socio-scientific issues (bSSIs) usually take the form of social dilemmas. Previous research has underlined the difficulties teachers face when they need to develop pedagogical plans for dealing with the social dimension of biological socio-scientific issues. These difficulties mainly refer to the lack of relevant materials and the need to provide students with decision-making heuristics. Our objective is to address these calls by presenting the template of 'Strengths and Weaknesses, Opportunities and Threats' (SWOT) analysis as a tool to address the social component in the study of biological socio-scientific issues. Such issues most often engage a series of social groups that have a stake in the issue at hand. For each stakeholder group, we can identify in-group factors that are decisive for the issue under study as well as factors that determine intergroup relations among stakeholders. In-group factors include beliefs, knowledge/skills, intentions, and behaviors that might either enable stakeholders converge and reach consensus in the issue under study ('strengths') or lead to divergence or conflict ('weaknesses'). Further, aspects of inter-group relations decisive for consensus involve possible fields of convergence or cooperation between stakeholder groups ('opportunities'), while aspects of inter-group relations that might lead to conflict include possible fields of divergence or competition between stakeholder groups ('threats'). The template has been pilot implemented by pre-service primary teachers that concentrated on bear conservation. Overall, 12 students (5th semester) participated in this pilot implementation, which took the form of a project. They interviewed members of stakeholder groups to determine 'strengths', 'weaknesses', 'opportunities' and 'threats' for all each group. We argue that the template of SWOT analysis can prove a valuable tool in addressing calls for decision-making heuristics, which could structure and scaffold inquiry in the social dimension of bSSIs. A pedagogical strategy that would concentrate on social heterogeneity and social actor dynamics seems to be able

to account for the context-specificity of sustainability. The template of SWOT analysis enables the investigation of points where stakeholder groups could diverge or converge and, thereby, enables the potential of seeking consensus and reaching solutions. This potential suggests a procedural conceptualization of sustainability), where the latter has to be experienced as a democratic deliberation process rather than as a pre-given end-state to be sought.

143. (Prospective) biology teacher's subjective theories about self-directed learning (sdl)
Christiane Hüfner and Matthias Wilde

Fox (1983) examined several empirical studies about teachers' thinking and deduced several basic 'theories of teaching'. The theories might be equivalent to subjective theories in the broader sense according to Dann (1994). An essential function of subjective theories is the strong regulation of teaching (Dann, 1994; Helmke, 2009). According to Fogarty, Wang and Creek (1983) an experienced teacher uses this knowledge more often and attunes it to learners. Fox (1983) subsumed mainly two categories, namely the developed and the simple theories. These vary in two main characteristics, the observation of internal learning processes in learners as well as the teacher's roles in it. The developed theories describe the learner as an active participant in his own learning. In this case the teacher contributes his experience and expertise to support the learner. An active learner and a supporting teacher are characteristics of sdl (Faulstich, 2001). In science education several ways to support sdl exist (Schraw, Crippen and Hartley, 2006), explaining the high interest in the topics. Also, self-regulation is an important aspect of academic performance in the classroom (Corno &Mandinach, 1983). The aim of the present study is to collect subjective theories from biology teachers about the process of sdl. It seeks to explore the nature as well as the development of conceptions of sdl by (prospective) biology teachers. Using a semi-structured, guided interview (Flick, 2011) allows uncovering the teachers' complex knowledge about sdl. Based on the example interview developed by Scheele and Groeben (1988) it is combined with a variation of structure-laying technique (Flick, 2011). Qualitative content analysis (Mayring, 2000) serves as a tool for developing different subjective (i.e. non-scientific) categories about sdl from interview material. Firstly, in order to uncover individual implicit knowledge, the interviewee has to answer open questions. The main points are individual importance, experience, implementation about sdl in biology class, e.g. experimentation, working with living beings or doing project-based scientific work. To handle those tasks the learner has to know how to monitor, regulate and perform his activities. These are meta-cognitive strategies (Corno, 1986), also important factors in the process of sdl. Thereafter, we try to reveal further questioning based on the scientific construct of sdl, according to Schiefele and Pekrun (1996), Schmitz and Schmidt (2007) and Zimmerman (2002) explicit knowledge of (prospective) teachers. For the study 32 interviews will be conducted.

107. Prospective Biology Teachers' Competence to Assess Pupils' Abilities to Experiment
Cora Joachim and Susanne Bögeholz

Experimenting is a central method in biology lessons to obtain findings (KMK 2008). The advancement of competencies in experimentation plays a prominent role in school (KMK 2005). Therefore, prospective teachers need a theory-based competence to assess pupils' abilities to experiment .

A theory-based model for assessment competence of Biology teachers is developed. The goal is to check assessment competence empirically as well as to develop a test instrument . The model for assessment competence in experimental biology lessons incorporates elements of experimenting that teachers should be able to assess. In consideration of Hammann's (2004) competence model of pupils' competencies in experimentation, the three dimensions: assessing high school students' achievement when 1) forming hypotheses, 2) planning experiments and 3) analyzing the data, build the framework for the model. For each dimension central criteria are defined.

For the development of the test instrument tasks to capture assessment competence are developed. The tasks incorporate specific methodological aspects of experimenting. The experiments take place within the contexts of seed germination and photosynthesis .

To get a first insight into prospective teachers' assessment competence and to expose difficulties in the tasks in order to optimize them, verbal reports were conducted (Ericsson & Simon 1993).

The verbal reports took place at the University of Göttingen in January and February 2013. 16 students studying Biology education took part in the verbal reports. These reports are analyzed by means of the qualitative content analysis according to Mayring (2010).

A first look into the material suggested that prospective teachers have difficulties to assess competencies in experimentation. For instance, when assessing high school students' hypotheses, many prospective teachers recognize an imprecise formulation, but often discover only one of several aspects that are imprecise .

The tested and optimized tasks serve as prototypes and reference for the development of structurally identical tasks in further contexts in order to develop a reliable and valid test instrument and to model assessment competence for competencies in experimentation .

A next step will be to test the optimized tasks in a written open-answer format with 60 students .

In the framework of the joint research project ExMo the assessing competence will be validated discriminately with planning and analyzing competencies .

A goal is to generate knowledge for the training of Biology (student) teachers. A long-term goal is to develop tests to diagnose the output of Biology teacher education as well as the effectiveness of specific interventions in this area.

150. The natural history perspective on bio-communities – using monographs in ecology education

Martin Jurgowiak and Jörg Zabel

Most students believe ecosystems to be in perfect equilibrium and static throughout time as long as they remain untouched (Jelemenská 2006). Biology education may have contributed to this problem, as it often focuses on describing biological entities and functional biology Kattmann (1995). Meanwhile, many curricula emphasize evolution as a unifying theme (e.g. Olson et al. 2012). Kattmann and van Dijk (2009) even go further by making a case for a natural history perspective in biology education: "Introducing historical narratives in secondary biology education can be a first step toward teaching evolution as the unifying theme that it truly is."

The focus of the paper is the development of a teaching unit 'the forest as a bio-community', which combines monographic elements with the interpretation of contingent events and the consequences they cause within the bio-community. Sommer (2008) investigated the systemic competence of primary school students. She discovered, that 9 year old students are able to predict dynamic changes within a system, if they have enough knowledge about how the system is organized. Monographs focus on facts about a certain population of a species and make it possible to elaborate on the interdependencies within a system. On this autecological level the students should be able to understand the dynamic changes of past, present and prospective interdependencies within this system.

When initially establishing a natural history perspective, it seems reasonable to choose students from the beginning of secondary biology education and bio-communities as a smaller grain size of ecological phenomena. The main objectives of this study are (1) to identify students' conceptions about the interdependencies between living beings and their environment, and (2) to find out if monographs are useful to procure a natural history perspective with this age group. By comparing the students' conceptions (grade 6, average age 12) of biocenotic development after a teaching unit with and without a natural history perspective, conclusions as to guidelines for teaching ecology including monographs and a historic perspective in biology education can be drawn. In order to investigate to what degree monographs and a natural history perspective actually promote an understanding of ecology, problem-centered interviews will be conducted. All Data will be analysed using Qualitative Content Analysis (Mayring 2007).

At the conference, findings related to students' conceptions of a pre-study and the developed teaching unit will be presented.

135. Plant Content of Greek elementary Study of the Environment textbooks

Marianna Kalaitzidaki, Christina Pantechi and Maria Ivrinteli

There have been reports in the literature documenting that students of different ages and of different countries lack knowledge and interest in plants. Plants are essential in sustaining life on earth and if this fact is not appreciated it may have implications in the public support of flora conservation and plant research. Since textbooks play a significant

role in science education especially in elementary level,this study analysed the Study of the Environment textbooks of first, second , third and fourth grade of greek elementary school for their plant content (space and topic), both in text and images. The study of the environment course is an interdisciplinary subject that combines elements of physical, life and social sciences. References to plants were present in all 4 grades (11, 48% in the first grade, 14.37% in the second, 10.29% in the third and 5.64% in the fourth grade. Most references were in the categories ecology (distribution, ecosystems, interactions) and economy (plants with economical significance). Least cited were the threats to plants and plant reproduction. Teachers should provide more information on these topics during intsruction and or enviornmental education activities.

4. A study on scientific inquiry through experiments in biology teaching - teachers` practices and views

Anja Kizil and Ulrich Kattmann

Based on the fact that German students have shortcomings in the domain of scientific inquiry, especially in the range of experiments and scientific reasoning, we focus in our study on German biology teachers` views on scientific inquiry through experiments in biology teaching, since the teacher plays an important role in the instruction process. For this purpose a qualitative research design was chosen. The aim of our study is to formulate recommendations for teacher education with respect to scientific inquiry in biology teaching. Data show that teachers either use effects or hypotheses as starting points and means of scientific inquiry. It becomes apparent that students have difficulties in drawing conclusions from the experiments, especially in regards to the hypotheses. We conclude that (1) the orientation on effects can be used meaningfully as means for scientific inquiry and that (2) predictions derived from hypotheses can support students in drawing conclusions and gaining scientific knowledge.

127. The Impact of an Ecology Unit on Secondary Students' Conceptions about Natural Sightseeing

Konstantinos Korfiatis, Stella Petrou and Maria Photiou

The appreciation of a landscape is differentiated among different people as they are influenced by their interaction with their environment. In the present research we study the effect of an ecological unit about trophic relations on students conceptions about which elements of a natural environment are worthy paying attention at. The research questions were: a) Which are students' conceptions about the characteristics of natural sightseeing? B) How they were affected by an ecology unit on trophic relations? 50 students (14 to 16 years old) of a private urban school in Cyprus participated in six, 90 minutes long, ecology lessons on the trophic relationships and the biodiversity in an human-made forest. Participants were asked to complete individually a word association task by listing five words that they could think about the given stimulus word 'Natural Sightseeing'. They then were asked to answered the following questions: (1)Which are the characteristics of a

natural sightseeing? and (2)Which are the characteristics of a natural path? The above procedure was implemented before and after teaching intervention. Data analysis involved content analysis of the word associations and the students' answers. As it concerns students' conceptions about the characteristics of natural sightseeing, participants in the present study realize it as a combination of natural and human factors even though they emphasize on natural factors. In relation to their conceptions about the characteristics of natural path, they focused on human elements before and after teaching intervention. This is a predictable finding because during their experiences in the artificial forest, they felt that there are not sufficient human services so their construction would satisfy human needs. Finally, the increase of students' statements about the importance of animals after the teaching intervention could be considered as an effect of their outdoor experience and more specifically of their involvement with the study of the trophic relationships of soil macrofauna.

47. Comparisons & Deductions of Teacher-students' problems with IBSE

Philipp Krämer, Stefan Nessler and Kirsten Schlüter

Inquiry-based science education (IBSE) is suitable to teach natural science contents as well as scientific skills. Similar conclusions are drawn by studies with respect to scientific literacy, vocabulary knowledge, conceptual understandings, critical thinking and attitudes toward science. Nevertheless, IBSE is rarely adopted in many countries, including German schools. Often barriers for teachers account for this lack, with the result that even good teachers struggle to teach science as inquiry. More importantly, studies indicate that several barriers and constraints could be ascribed to problems teacher-students have .

The aim of our research project is to identify and compare problems teacher-students have with Inquiry-based Science Education. In order to draw a holistic picture of the problems, we identified and categorized problems on three different levels: i) problems observers state objectively, ii) problems the teacher-students perceive subjectively and iii) problems the teacher-students notice reflectively from a metalevel. Using open questionnaires and qualitative content analysis as well as video analysis and observation sheets, we were able to find distinct problems on each level .

Overall, teacher-students have many highly diverse problems concerning IBSE. While objectively stated problems reflect issues regarding IBSE as a teaching method itself, subjectively perceived problems seem to characterize prevalent barriers. However, reflectively noticed problems comprise problems with classroom management. Comparisons of the three levels as well as deductions drawn from the comparisons lead to severe contradiction between what teacher-students fear and what observers observe.

89. The relationship between epistemic beliefs and systems thinking in biology: Differences in epistemic judgments of German primary and secondary school teachers & changes of epistemic beliefs in a biology course on systems thinking

Tim Kramer, Elmar Stahl and Werner Rieß

Systemic thinking and the qualification to teach systemic thinking is seen as a fundamental competence of (German) biology teachers, e.g. in the context of education for sustainable development .

Dealing with different (biological) systems requires to deal with highly complex contents, interdependency of elements, and controversial information .

Therefore, it is required to accept non-linearity, uncertainty and, to a certain degree, unpredictability - all features of certain epistemic beliefs. For this reason, we assume that teachers´ competence of systemic thinking and the competence to teach systemic thinking should interact with their personal epistemic beliefs. Further on, we assume that even dealing with complex topics should effect the epistemic beliefs of the teachers and teacher trainees .

In a mixed method design, epistemological judgments of biology teachers working in different German primary and secondary school types (Gymnasium, Realschule, Hauptschule, Grundschule) are examined. As theoretical background the idea of a generative nature of epistemological judgments presented by (authours, 2008) and (author, 2011) is used. The study is especially interested in understanding how teachers justify their epistemological judgments and whether systemic differences in their justifications can be found in relation to the school types. Furthermore it investigates whether epistemological judgments are stable between different controversial contexts .

In the qualitative part ,teachers are asked in a semi-structured interview to judge statements dealing with complex and controversial issues concerning biological topics (N=23). Based on these results, an online-survey (N>200) for the quantitative part is developed and results will be presented at the conference .

Another part of the project investigates changes of epistemic beliefs during a continuing education biology course on systemic thinking and how to teach systemic thinking in schools, mainly by students writing a learning journal. There were three intervention groups, each receiving 14 lessons altogether. The first group only had lessons upon expert knowledge concerning biological systems and system sciences; the second group learned both, expert knowledge and PCK (pedagogical content knowledge to promote systems thinking in lessons) mixed; and the third group only had lessons concerning PCK. The interventions for all groups were parallelized in terms of duration, structure and phases of teaching and learning .

First findings show :

- It is possible to foster epistemic beliefs in courses on systemic thinking in biology .
- The effect on epistemic beliefs is larger in the group with expert knowledge concerning biological systems and system sciences than in the group with paedagogical content knowledge or the group with a mix of both .

- Teachers of different German school types differ in their understanding of science and in their epistemic judgments .
- Teachers of all groups argue systematically different in different contexts.

42. Biology Teachers' Conceptions about Models and Modelling in Science
Moritz Krell

This study was based on the 'model of model competence' in which the five aspects nature of models, multiple models, purpose of models, testing models, and changing models are distinguished and each further subdivided into three ordinal levels of understanding. Biology teachers' (secondary schools, Berlin, Germany, N=146) understanding of the five aspects was assessed using open-ended questions. In addition, rating-scale items were used to investigate to what extent the teachers discuss each level of understanding in their biology lessons (teaching activities). The findings propose that most biology teachers do not perceive the notion of models as hypothetical entities and research tools but rather understand them as copies or depictions of an original. A relation between teachers' understanding of models and modelling in science (open-ended questions) and their teaching activities (rating-scale items) was found only in some aspects. At the ERIDOB conference, further findings concerning the relation between teachers' understanding of models in science, their teaching activities and several control variables (teaching subject, teaching experience, type of school) will be discussed.

108. Student-monitored learning for sustainable development - does it bridge the gap between formal and informal science education
Yelva C. Larsen, Jorge Groß and Franz X. Bogner

Up to now, just a few studies have dealt with the importance of monitoring in the process of informal learning, leaving it open whether an application of student-monitoring can combine formal and informal learning characteristics. We compared cognitive and affective outcomes of self- and peer-monitored intervention groups that visited an interactive and multimodal exhibition devoted to the topic of bioenergy. To demonstrate the variety of application forms of renewable solid, liquid and gaseous fuels we developed eight interactive and multimodal exhibits. In 2011 the exhibition was awarded an official „UNESCO Decade Project for Sustainable Development". In total, 470 students (8th/9th grade, lowest stratification level) participated at the study and filled out paper-and-pencil responses. A pre-, post- and retention-test schedule was applied to monitor pre-knowledge as well as the short- and long-term learning effects of the self- and peer-monitored group. Additionally we assessed students' intrinsic motivation (perceived competence, perceived choice) and situational learning emotions (sensation of anxiety, boredom, interest and wellbeing). The self-monitored group (n=218, ♀: 47.7%) and the peer-monitored group (n=230, ♀: 49.4%) took both part at our half-day programme that included a preliminary session, a workbook-guided visit of the exhibition and a debriefing session .

Both intervention groups demonstrated a highly significant increase in short- and long-term knowledge, showing that also a very complex topic as bioenergy can be effectively learned without teacher-monitoring. Additionally, by controlling pre-knowledge and gender by using multilevel statistical modelling, the peer-monitored instruction proved to better improve cognitive learning outcomes. It is surprising that peer-monitoring increased perceived competence and simultaneously reduced the perceived level of anxiety and boredom. Consequently, when highlighting cognitive and affective outcomes, peer-monitored instruction clearly exceeds a self-monitored focus.

92. Expressions of science literacy in authentic online public discussions following climate change news coverage

Esti Laslo and Ayelet Baram - Tsabari

Human influence on climate is at the core of the public debate on global warming. This debate is characterized by a gap between the scientific consensus and public perception and knowledge. The aim of science education in the last decades is to educated scientifically literate citizens, who are able to make informed decision in socio-scientific issues. We follow the theoretical framework of Feinstein 2011, who advocates defining science literacy based on authentic use of science in everyday lives. Here we investigate the manifestation of scientific literacy in the authentic environment of public reader comments to online coverage of climate change in a leading news website. The analytical framework for analyzing the comments is based on the school biology curriculum, in order to describe how the aims of school science are echoed in an authentic public engagement with science setting. For this reason, the formal Israeli science curriculum was adopted, and the comments were analyzed with regard to knowledge, inquiry skills, nature of science perceptions, and setting informed positions. This presentation describes results with regard to content knowledge. Data source included 648 reader comments submitted to climate change articles during October 2011 to March 2012 in Ynet, the Israeli leading online news site. Scientific knowledge was assessed based on the use of science concepts, which were classified according to their level in the Israeli science curricula: Elementary school (e.g. volcano); Junior high school (e.g. global warming); High school (e.g. positive feedback), and concepts in an academic level (e.g. particle accelerator). Findings indicate that reader comments presenting clear positions used more and higher level science concepts than those presenting no opinion. The concepts level of the comments which accept the idea of human influence on climate change were significantly lower comparing to the number and level of concepts used by reader comments denying such influence. The findings challenge the traditional deficit model which views public disagreement with scientists as a consequence of ignorance, while scientific literacy found as not necessarily correlated with pro-science positions.

57. Supporting Outdoor Inquiry by Mobile Technology

Keren-Sarah Levy, Tali Tal and Yael Kali

Inquiry-based learning in the outdoors is a central component in biology and environmental sciences in Israel. In general it supports and deepens student understanding of abstract scientific ideas, and it is known for its potential in developing cognitive, affective and social outcomes. However, teachers avoid guiding their students in the outdoors due to various challenges: technical-organizational and pedagogical. Mobile learning may support inquiry-based learning in the outdoors and encourage teachers to guide their students independently. This research aimed to explore the ways mobile learning supports inquiry learning in the outdoors. The study took place in the Ecological Garden (EG) of the university, where 22 pre-service teachers participated in a field trip as a part of "Teaching inquiry projects" course. Three technologies were selected: a) a course website, b) Tumblr App for data sharing and c) Google collaborative docs for arranging and analyzing data. Data collection included observations during the activity in the EG, reflective questionnaires and student work in Tumblr and Google docs. Analysis of the observations showed that one third of the students used smartphones or tablets throughout the EG activity for taking pictures and shooting videos of their work, but they used pencil and paper for actual documentation of data. Six teams used Tumblr for uploading posts. The questionnaires indicated students acknowledged the mobile technology contribution to individual learning processes, and to multiple interactions between learners and technology, among peers, between learners and the environment and between learners and the instructor, all of which reflected cognitive, affective and social outcomes. The majority of the participants indicated the useful support given by the website and the classroom activity prior to the field activity and the usability of the tools. A few felt they needed another experimentation of the tools. Difficulties using the technological tools were associated with technical connectivity problems, insufficient experience with the technological tools and the smartphones' small screens. These findings suggest that mobile learning can help teachers overcome some of the challenges regarding teaching ecological inquiry in the outdoors by supporting the inquiry process. The technology also enables the learner to focus on the environment and enjoy nature. The course website provided a supportive environment for the entire inquiry cycle, and provided many resources for the learning process. In summary, the technology support was shown to be helpful regardless of the environment where the inquiry project takes place.

62. Towards acquiring pro-environmental attitudes through environmental education: Do age and sex cause effects?

Anne K. Liefländer and Franz X. Bogner

Enhancing pro-environmental attitudes through education is an important but inevitably slow process (Bogner, 1998). According to Piaget’s developmental theory, the age groups ‘7 to 11’ and ’11 and older’ fall into different developmental stages, the ‘concrete operational stage’ and the ‘formal operational stage’. Within this context, we aimed to compare the

two stages according to their environmental attitudes and a possible enhancement of attitudes through participation in environmental education. The four-day programme at an educational field centre for 9-10 and 11-13 year old pupils was assessed with the dimensions preservation (P) and utilization (U) of the 2-MEV model (Bogner & Wiseman, 2006) in a pre-, post-, retention test design. We found, our younger pupils held more pro-environmental attitudes than the older ones before programme participation (P: $t = 4.90$, $df = 265$, $p < .001$, $r = .29$; U: $t = -2.14$, $df = 265$, $p = .033$, $r = .13$) and the attitudes of the younger pupils also enhanced stronger through programme participation (P: $F(1, 577) = 88.58$, $p < .001$; U: $F(1, 577) = 22.82$, $p < .001$). We could not detect differences between male and female pupils, neither for the younger nor for the older pupils. Concluding, educational programmes may enhance environmental attitudes regardless of pupils sex, though more effective (or faster) in younger pupils.

139. Enhancing the authenticity of inheritance in biology subject through socio-scientific issues and values in biology education

Stella Magid

With the aim of increasing authenticity and relevancy in the genetics' learning process in Biology education, we used a Web-based module about simple inheritance, which was originally proposed by Berkeley university for American students and was adapted by us for an Israeli context. We increased the relevancy of the module through an anchoring (real) story of fundraising for cystic-fibrosis (CF) patients and also presented some moral socio-scientific dilemmas regarding the usage of money from fundraising, in different aspects of life, such as: medicine, research, industry etc. We also added interactions with CF patients using two types of interactions: (1) a field-trip to a CF hospital unit; (2) online a-synchronic interaction with CF patient through educational forum .

We assumed that the use of socio-scientific issues in a scientific subject (biology), would expose students not only to the pure science along with its processes and rules, but also to human aspects and values which are relevant for the students' lives and can contribute to their value-systems in a long term process .

The goal of the research was to explore the process of learning through the module and determine how the hospital-visit and the online interaction with a patient contributed to the students' interest and understanding of genetics .

The pupils from one 10th grade class visited the hospital and the pupil of another communicated with a patient. By using pre/post Knowledge-Integration tests, feedback questionnaires, observations in class and the students' recorded work in the web-based module, the results show that the adapted-module, which included a framework of moral issues which fit the Israeli life context, contributed to students' interest in genetics even without the added activities (field-trip and online interaction). Project features such as involving students in making decisions through different activities in the module, were crucial for engaging the students and promoting their interest in genetics. There was no

difference in knowledge acquisition, but there was a significant difference between the groups' engagement.

33. How Does Biology Teachers' Professional Knowledge Influence System Thinking of Students?

Daniela Mahler, Jörg Großschedl and Ute Harms

Biology is the science of living systems. Consequently, fostering system thinking is a central task of biology education. Although it can be assumed that teachers' content knowledge (CK), pedagogical content knowledge (PCK) and curricular knowledge (CuK) have an influence on students' system thinking, there are no empirical studies investigating the relationship between teachers' CK/PCK/CuK and students' system thinking. System thinking abilities of 1036 students (8th and 7th graders) were analyzed in a pre-post-test-intervention study with questionnaires. 41 teachers were asked to develop a teaching unit on an ecosystemic topic, the 'Blue mussel in the ecosystem Wadden Sea'. Subsequent to the teaching unit they ran a test concerning their CK, PCK, and CuK .

A multilevel-analysis was conducted to investigate the influence of teachers' CK, PCK, and CuK on students' system thinking. The multilevel analysis shows that biology teachers' PCK has significant influence on students' system thinking in biology .

Our results offer first insight into the relationship of teachers' PCK and students' system thinking abilities on the one hand. On the other hand they - once again – document the necessity to foster teachers' PCK development in teacher education to ameliorate teaching and learning in biology at school.

77. Use of a Concept Inventory to probe student learning and to inform faculty professional development

Gili Marbach-Ad

This study explores the use of a diagnostic assessment tool - concept inventory (CI) - to probe the learning progression of undergraduate microbiology students. As a research faculty with expertise in the area of host–pathogen interactions (HPI), we have worked collaboratively since 2004 to engage students in meaningful learning of HPI concepts. We formed a faculty learning community, which included faculty members with research programs in HPI, instructors with significant experience in teaching and curriculum design, and a faculty member with expertise in science education. Our overarching goal has been to create bridges between our courses, eliminate excessive overlap in our offerings, and support a model where concepts and ideas introduced in one course would become the foundation for concept development in successive courses. In order to develop such a continuum between our courses, we worked on curriculum and teaching approaches simultaneously with assessment. To this end, we developed a concept inventory (HPI-CI). The HPI-CI consists of 18 multiple choice questions where each distractor represents an alternative conception (also known as misconception). Following each question, students are asked to provide an open-ended explanation for their answer selection. From these

responses, we learn how students articulate HPI concepts, the terms they use, and the connections they make between concepts. The CI was administered prior to and following each course in the undergraduate microbiology curriculum, which involve nine undergraduate courses (one introductory course and eight upper level courses). We have previously reported findings from quantitative analysis of HPI-CI data. Here we present our ongoing work on the analysis of the open-ended explanations, and the building of a database of alternative conception themes in HPI and their origins. We first focused on data from the pretest in the introductory course, General Microbiology, since it has the largest enrollment, is a prerequisite for all the other courses, and serves the most diverse audience. We reviewed 694 open-ended responses generated from the pretest for students enrolled in a general microbiology course over three semesters. Through the analysis of students' explanations, we found that many undergraduates in microbiology courses hold alternative conceptions that seem to originate in middle school and high school. In the conference we will provide examples alternative conception themes, and suggest how these may be addressed via targeted curriculum activities. This project is providing insight into student learning and serves as a model for enhancing faculty development in teaching.

148. Evaluation of pre-service science teachers' competencies in scientific inquiry using multiple-choice items

Sabrina Mathesius

This study is part of an international collaboration of the departments of biology education, chemistry education and physics education at four universities and aims to model and measure competencies of pre-service science teachers. Teachers' professional knowledge is one of the central aspects of successful education (Hattie, 2009). That is why it has to be of huge importance to evaluate the so far neglected teachers' education. Therefore, a paper-pencil test with 166 items was developed using the responses of 300 pre-service science teachers for the two scientific inquiry methods conducting investigations and using models. In a pilot study, this test was answered by 430 pre-service science teachers compared with 132 science students. The data, which will be presented at the ERIDOB conference, refers to 47 items concerning biological problems in the field of scientific inquiry seen as a problem-solving process (Mayer, 2007). As the research project is conducted as a longitudinal study in two countries and across four universities, we will investigate the scientific inquiry competencies through four observations within a large-scale assessment. Thereby, the development of the competencies of pre-service teachers during their pre-service teacher education will be analyzed. At the ERIDOB conference, results of the first observation will be presented as well as those relating to cross-sectional analysis of the data from around 2000 academic students.

78. System Competence Modelling (Symposium: Systems Thinking)

Rainer Mehren, Armin Rempfler, Janine Buchholz, Johannes Hartig and Eva Marie Ulrich-Riedhammer

The basis of the research project, which lasted three years and was supported by the German Research Association (DFG) as well as by the Swiss National Science Foundation (SNF), is a normative/educational theory-based geographical and environmental system competence model for secondary school students. The first part explains the significance of systems thinking respectively system competence in the context of geography and environmental education and describes the suspected dimensions, based on the current theoretical and empirical state of knowledge. A solid system theory foundation which addresses the core concern of geography and environmental education is offered by a socio-ecological system understanding. It is based on system characteristics that can be applied to physical geographical and human geographical aspects as well as human-environmental issues. These characteristics are fundamental to the normative development of a structural and stage model for geographical and environmental system competence. The second part explores the diagnostic tools to be used for the empirical verification of the postulated dimensions and stages of the competence model. A tool based on educational theory for the valid, reliable measurement of system competence is the ultimate objective. According to the initial results shown in part three, the model in conjunction with the test problems might be able to permit a criteria-oriented application within the framework of academic diagnostics.

25. How can higher education contribute to the development of sustainability literacy? The case of an Israeli university

Keren Mintz and Tali Tal

Education for Sustainability is defined as education that aims to prepare people to cope with and find solutions to problems that threaten the sustainability of the planet. Higher education (HE) plays an important role in promoting sustainable future since HE students are tomorrows' citizens, professionals, and decision makers. A major challenge in HE is designing educational activities that promote the development of sustainability literate graduates. To promote this goal multiple learning outcomes should be enhanced, and sustainability ideas should be integrated in all programs. The aim of this study is to explore the ways different learning experiences promote sustainability literacy of HE students. The research questions are: 1) How do students perceive the contribution of their study period to their sustainability literacy? 2) What types of learning experiences are viewed by the students as most significant in promoting the development of sustainability literacy? The research took place in a leading science and engineering university. Data were collected through online questionnaire that consisted of open-ended and closed items. Overall, 386 students returned responses; they represented a variety of majors and learning experiences in terms of formal and informal activities that integrate sustainability. The main findings are: a) a positive moderate and significant correlation between number of courses

student enrolled in that deal with environmental issues, and perception of the learning period as contributing (rs=0.5 p<0.001); b) about half of the students reported on a change in their attitudes and knowledge regarding environmental issues and sustainability, but only 10% explicitly described university learning as the main reason for this change; c) many participants emphasized the fact that much of their learning focused on being efficient professionals and gaining technical knowledge rather than learning environmental issues or learning about how engineering affect the environment; d) learning experiences that were recalled as most significant were mostly of active learning; e) promoting environmental issues was described mainly with regard to specific behaviors, and very few participants described a more holistic understanding of sustainability living. The main conclusions are: a) participating in courses that deal with environmental issues have a certain affect on students knowledge and attitudes regarding sustainability, yet it does not necessarily guarantee the promotion of sustainability literacy; b) active learning has a potential to enhance a more significant learning; c) in some cases courses in HE, mainly in engineering and science, might focus on economic efficiency but ignore environmental aspects.

110. Teachers' processes involved elaborating media corpus to treat the GMOs socioscientific issue within the classroom

Grégoire Molinatti and Ariel De Bernardo

In this study we were interested in the use of non-instructional mass media by science teachers in the context of treating issues that are societally relevant (including political, economical and ethical factors) and rooted in science, labeled socioscientific issues (SSI). Our research fits in the theoretical framework of SSI education and media literacy education. Here we analyze a media corpus assembled by a group of teachers and researchers, who aimed to introduce in school, the handling of the controversy on the use of agricultural GMOs. We analyze the reasons that governed the choices done by the group, on the selection of documents. The corpus offered to the students is adapted to manage the mediatized, expertized, and complex dimensions of the controversy. Meanwhile it is essentially made reference to limited scientific valuations and not to professional experts or profanes. The selected documents respond to the restrictions of pluridisciplinarity, didactical organization, and the intelligibility for the high school students. Finally the retained corpus does not give a neutral opinion of the controversy, which leads us to discuss the individual and collective postures of the teachers and researchers involved, that remained partially implied.

22. The impact of metacognitive awareness and system thinking instruction on the understanding of the biological core concept homeostasis

Moriya Mor, Michal Zion, Bruria Agrest and Ruth Mendelovici

Homeostasis is a core concept in biology curricula worldwide. Biological systems, such as Living organisms, are complex systems. Understanding homeostasis requires system thinking. Previous studies on students' understanding homeostasis explored difficulties in

system thinking comprehension. Recent research indicates that learners who have metacognitive awareness perform better in science teaching than learners without metacognitive awareness. In the present study, we examined the impact of combining metacognitive and system thinking instructions on `homeostasis` understanding. Both instructions were embedded using tasks focused on understanding homeostasis in the human body. The current study assessed four learners' groups, who performed the same learning tasks; each group received a different combination of instructions. One research group received the two types of instructions, the control group received no instruction and two others received only one instruction. Pre and post questionnaires on homeostasis were administered and analyzed both qualitatively and quantitatively. Results showed that each one of the instructions, as well as the combination of both of them, improved students' understanding of homeostasis. The metacognitive and system thinking instructions we developed can be used as an instruction model which promote students' understanding of homeostasis specifically and others biological concepts in general.

130. Using concept maps to foster students' understanding and socioscientific reasoning about climate change

Anne Nitsch, Sabina Eggert, Susanne Bögeholz, and Matthias Nückles

Climate change - its causes and consequences - is probably the most challenging problem of today's global society. The need for climate literate persons, who understand the underlying principles of our Earth's climate system and are able to reach informed and responsible decisions with regard to actions that may affect climate, has been identified as one key component of scientific literacy (e.g. USGCRP, 2009). In this respect, science education plays an important role in supporting students' learning about complex socioscientific issues such as the issue of climate change .

The aim of the present study was to develop a computer-based learning environment to support secondary school students' understanding and reasoning about climate change and possible solution strategies. In more detail, different concept mapping support measures were used to support students' in visualising their learning processes .

Participants included 158 secondary school students (mean age = 17.16). Students studied in four different training groups that varied in the degree of support measures given: Students either constructed concept maps without any additional support (n=38) or were given relevant concepts (n=37) or relations (41). Finally, students in the fourth training group worked in a highly pre-structured concept mapping environment that provided both relevant concepts and relevant relations between these concepts (n=42), which they only had to spatially arrange .

Data analyses included both the quality of students' generated concept maps as well as their learning outcomes with respect to conceptual knowledge about climate change and socioscientific reasoning and decision making .

Results suggest that the different concept mapping support measures supported different cognitive processes during map generation. Providing students with relevant concepts

fostered the generation of high quality concept maps with respect to conceptual interdisciplinary knowledge about climate change. Providing students with relations that supported their reasoning and decision making processes fostered the generation of high quality concepts maps with respect to the pros and cons of possible solution strategies. Interestingly, students who studied with provide concepts and labelled lines generated qualitatively weaker concept maps, which may be a result or overscripting effects. In contrast, students who generated concept maps without any support measures generated high quality concept maps as well. Analysing students' learning outcomes on the pretest-posttest questionnaire indicate an increase in conceptual knowledge and socioscientific reasoning and decision making across all training groups. These results provide important implications for the development of computer-based concept mapping environments for complex socioscientific issues.

34. Energy as a Cross-Cutting Concept: Empirical testing of the interdisciplinarity of energy understanding in grade 6-12 students (Symposium: Energy)

Sebastian Opitz, Ute Harms and Knut Neumann

Energy as an interdisciplinary concept and a core idea has found entrance into curricula and science standards internationally since it is considered to foster deeper analysis of various contexts if students re-apply the concept. Due to its interdisciplinary character and its re-occurring significance for science contents from elementary school onwards, energy is also considered to support meaningful learning in the sense of assimilation learning theory. However, very little research is available as to students' ability to also use energy across disciplinary boundaries. This study addresses students energy concept development in the three science disciplines biology, chemistry and physics from grade 6-12, focusing on the structure of the developed energy understanding. We conducted a cross-sectional questionnaire study with items developed on the basis of a common energy model (Neumann et al. 2013). Following piloting of the developed items, N=969 students energy understanding was assessed using dichotomously scored multiple-choice items with crystallized intelligence as a control-variable (Horn 1983).Primary data analysis indicates high reliability of the employed items (α=.89). Students show significant development in their energy understanding from grade 6-12. On average, energy understanding was further progressed in the items from physics education, while performance in biology and chemistry was similar at each of the grade levels. Differences in students' understanding with respects to the different aspects of energy understanding may reflect a different focus on energy learning in each subject. Further analysis is currently conducted using structural equation modeling (SEM) to identify, if students develop a more integrated, interdisciplinary or rather a discipline-specific understanding of energy. The implication of these findings can provide an empirical basis for the improvement of science education standards with respect to interdisciplinary learning of the intended cross-cutting concept energy.

40. A qualitative analysis of the factors making the conceptual ecology of the evolution theory in Greek secondary school teachers

Penelope Papadopoulou, Efstratios Katakos and Kyriacos Athanasiou

In this study, we aimed to explore the factors related to the acceptance of evolutionary theory among biology education teachers using conceptual ecology for biological evolution as a theoretical frame. This paper explores, by the use of qualitative analysis, some of the factors that constitute the conceptual ecology of evolutionary theory of Greek secondary school teachers and the relationships between the findings of quantitative and qualitative research .

In this study eight interviews have been performed with teachers of different academic backgrounds (biologists, geologists, physicists, chemists) who teach biology in secondary education .

These interviews were analyzed by using NVivo 8.0 qualitative analysis software. The basic actions performed were the categorization of interviews content into thematic categories (nodes) and the subsequent exploration for common patterns and relationships among categories .

This qualitative analysis revealed the views and the attitudes of the teachers on the examined factors of conceptual ecology. Also explained and documented in some degree the results of the previous quantitative research in a large sample of biology teachers

The results support the initial research hypothesis that the factors related with evolution theory acceptance, their mix and their weight, differ in correspondence with local conditions and singularities and the total sociocultural environment. This is a very strong argument in favor of the approach of conceptual ecology.

90. Children's conceptual change in evolution following an educational science theatre play

Ran Peleg and Ayelet Baram-Tsabari

Despite the importance of understanding evolution for many scientific concepts, its acceptance in many countries is low. Acceptance of evolution is often hindered by prior conceptions that develop at an early age. Museums and other informal learning environments can play a significant role in modifying such prior conceptions and prompt conceptual changes. This study adds to the empirical evidence on learning evolution in informal learning environments by investigating how an educational science theatre play on basic evolutionary concepts can aid children's conceptual change. It is unique in two ways: (1) most studies thus far concentrated on museum exhibitions; (2) the young age of its subjects. The theoretical framework is based on conceptual change theory.

Participants were children visiting a science museum with their parents (103 viewers of the play, 90 non-viewers; average age ~8). A quasi-experimental posttest only design was adopted with data collected by a specially developed questionnaire. The play, "Darwin’s Journey" was produced in a major science museum in Israel and discusses two major ideas:

(1) Living things are adapted to their environments; (2) Animals evolve over time from common ancestors .
Findings indicate that audience members successfully recalled these two ideas as seen by questionnaire data. Viewers provided significantly more explanations involving adaptation to the environment than non-viewers did in three questionnaire items (this idea is discussed explicitly in the play). However, the rate of explanations involving evolution was equally low for both groups (this idea was not discussed explicitly in the play). Viewers also provided significantly more answers showing the evolutionary link between humans and monkeys (discussed explicitly), but not between other animals (not discussed in the play .(
It seems the audience recalled these two basic concepts successfully, but could not transfer them to cases not discussed in the play. One difference in reasoning pattern we could track was an abandonment of creationist reasoning patterns.

131. Investigating Pre-service Teachers' Environmental Values through Environmental Scenarios

Stella Petrou, Konstantinos Korfiatis and Maria Photiou

Environmental values are personal and social beliefs which are related to the nature's importance and welfare (Reser and Bentrupperbaumer 2005). Indeed, values correlate with the way that humans interact and manage the natural resources in local and international level. Exploring environmental values of students-teachers is of particular interest because it not only reveals their stance on environmental issues, but it can also empower them to work on the issue of environmental values together with their future students. Specifically, the objectives of the present research are: a) to study pre-service teachers' environmental values, b) to investigate if pre-service teachers adopt the same values in all instances in their life. The research was completed by a sample of 22 students-teachers of the University of Cyprus. Participants were asked to complete individually a test which included four multiple choice environmental scenarios. They then answered two open-ended questions: 1)Were your responses to the above scenarios based on a)concern for self b)concern for others c)concern for the biosphere? Explain your answer. 2) Your decisions in your life are based on a)concern for self b)concern for others c)concern for the biosphere? Participants needed approximately 30 minutes to complete the test. As it concerns the data analysis, the possible answers to each of the four scenarios were categorized as: a)Anti-environmental Statements, b)Neutral Statements and c)Pro-environmental Statements. The participants' responses to the open-ended questions were content analysed and classified into categories. Participants referred different values orientations but most of them adopt mainly ecocentric values. This result is in accordance with previous studies denoting that nowadays adults tend to adopt a rather pro-environmental profile (McMillan, Wright & Beazley, 2004; de Groot & Steg, 2010). Another possible explanation for this finding could be participants' involvement with environmental issues during their lessons. Participants particular interest and sensitivity about fauna could be attributed to the plants' inability to make eye contact, communicate by sound and exhibit behaviours (Strgar, 2007). Finally,

participants mentioned that they adopt different value- orientation depending on the situation. The most probable reason for this result can be explained by adults' moral stage in accordance with Kohlberg's theory of moral development.

124. Knowledge and misconceptions of natural selection among science students and biology graduates in university education

Rianne Pinxten

Educating students about evolution through natural selection is vitally important because it is one of the structuring themes in biology. However, educational research has revealed low levels of evolutionary knowledge, not only among secondary school and non-science students, but even among science students and biology graduates. A fundamental problem is that many students hold high levels of misconceptions about basic evolutionary principles. Since misconceptions are a major factor affecting how and if students learn, they should be explicitly identified and addressed during instruction. At present, there is little information available regarding the understanding of natural selection among science/biology students in university education, and regarding their effective gain in understanding throughout education. We investigated the level of understanding of natural selection in university education in Flanders, Belgium by addressing the following 2 questions: (1) What magnitude of knowledge of key concepts of natural selection and which misconceptions characterize (a) science/biology bachelor freshmen and (b) biology master graduates? (2) To which extent is this related to the amount of science education and the specific educational network ('GO! Education of the Flemish Community' versus the 'Catholic schools') during secondary school education (for bachelor freshman), the amount of specialized evolution education during university education (for biology master graduates), and students' background-variables. We used 'The Conceptual Inventory of Natural selection (CINS)', a 20-item multiple choice test, which was designed to measure students' understanding of 10 underlying key concepts (biotic potential, population stability, limited natural resources, limited survival, variation within a population, variation inheritable, differential survival, change in a population, origin of species, origin of variation), and the distribution and magnitude of misconceptions (the 3 distractors in each item address common alternative conceptions). Analyses of the test results are still under progress at the moment. Preliminary results obtained so far indicate that science bachelor freshmen earned a mean score of 12, with a range of 6-20. When considering the understanding of each of the 10 key concepts, the knowledge of 'limited natural resources' and 'limited survival' appeared the highest while the understanding of the key concepts 'variation inheritable' and 'change in a population' was the lowest. Bachelor freshmen that followed the most advanced science programs during secondary school education had a better understanding of natural selection, while the specific educational network students were enrolled in and gender had no significant effect.

58. Agro-biodiversity in science lessons - implementation and evaluation of a lesson concept to develop the students' aesthetic judgment exemplified by the soybean

Martha-Daniela Queren and Carolin Retzlaff-Fürst

Scientists have discussed the loss of biodiversity since the 1980s (Wilson, 1988). In Germany there is a public awareness for specific problems such as the forest dieback ("Waldsterben" phenomenon) or the loss of the tropical rainforests. The main reason is that media tend to focus on such environmental problems (BMLEV, 2007). The concept of "Agro-Biodiversity", however, remains unknown to the public (Cox & Wood, 1999). This becomes obvious already at school. Students neither have sufficient knowledge about species nor are they informed about their meaning for humans (Wandersee & Schussler, 1999). Environmental education research has proven that students are willing to deal with this. Studies have also illustrated that students are more likely motivated about the topic if there is an emotional relationship with the organism (Retzlaff-Fürst, 2001). The beauty of an organism has turned out to be a factor for positive emotions. This quantitative analysis has shown the students' judgement concerning the soybean as one of the human's key agricultural crop. The technique used for this examination was designed as a pre-, post- and follow-up test. Furthermore, it was supported by the aesthetic education's concept of form and content (ebd.). Based on this examination, the students' expert knowledge about agro-biodiversity was examined. Moreover the examination recorded the development of the knowledge, the aesthetic judgement, sustainable thinking and acting over the teaching unit. The study has been finished and evaluated. The results will be presented.

19. Why do these beans smell? Explanation of a complex phenomenon by teacher trainees.

Maria J. Gil Quilez and Begoña Martinez Peña

This study analyses trainee teachers' explanations of a certain phenomenon: the peculiar smell beans give off after being in water for several days. The purpose of this study is to answer the following questions: Which processes do students consider in their explanations? Which causal relationships do they establish between these processes? Which role do empirical results and theoretical frameworks play in arriving at conclusions?. The experiment was conducted with 111 students in the third year of their teacher training course as part of the biology and geology teaching subject .

The students worked together in groups and they set out and discussed the answers in two 60-minute sessions. To ensure the students established a link between empirical and theoretical data, they had to produce a Gowin's V diagram. This was also discussed in two other sessions .

The following aspects were taken into consideration to analyse the replies :

-Variables: bean, microorganisms, time elapsed, other variables

-Characteristics: characteristics of the bean (seed), nature of the smell (why do we perceive smells), characteristics of microorganisms (size, metabolism, reproduction (

-Interactions: if there is just one cause / several causes / causal reciprocity (causes and effects become confused). If causality is linear / systematic.
-Theoretical framework relationship with empirical data: responses based on theoretical data, on empirical data observed in class, on both types of data, they only mention the overall process (not backed up).
The variables mainly used to explain the phenomenon in the answers were: moisture (60%), temperature (57%) and time (53%). Surprisingly, bacteria were only considered by 25% and beans by only 38%. Interactions, the processes that take place, are not used to explain the changes they observed. The students have an anthropomorphic view of bacteria
The students expound the conceptual part of the V, pointing out the concepts involved in the phenomenon. However, the record of evidence is incomplete. They do not indicate the physical change in the beans or the chemical change in the water. This makes it difficult to establish links between empirical and theoretical data .
The activity presented here contains a highly educational content, since virtually every operation (identifying the variables, analysing and linking them) could lead to a multitude of questions and hypotheses requiring research. Furthermore, the various responses could be the main force behind making the knowledge taught in classrooms more complex. In other words, they would result in the construction of gradually more complex biological models.

99. The impact of stereoscopic 3-D on constructing and correlating multiple external representations of a human biological topic

Martin Remmele and Andreas Martens

Comparing 2-D to stereoscopic 3-D visualisations as single representations, research has shown advantages of stereoscopic displays on tasks applying spatial information as judging positions, navigation and spatial understanding. There is also evidence that multiple external representations as combinations of visualisations (depictive representations) and text (descriptive representations), in some circumstances, support construction of deeper understanding. However, less evidence is known if – and if so, in which cases - stereoscopic 3-D visualisations may foster better than 2-D visualisations - both combined with text - the appropriation of biological topics. Thus, our study focuses on an e-learning environment dealing with the nasal cavity applying (1) text and 2-D visualisations or (2) text and stereoscopic 3-D visualisations. Prior objectives were to compare the impact of 2-D vs. stereoscopic 3-D visualisations on learners creating an anatomic structural model of the nasal cavity (considered as an example of a depictive representation) and describing an issue-specific physiological topic by filling in a concept map (considered as an example of a descriptive representation). In addition, we monitored how these representations could be correlated by the students .
The study was carried out with 120 eighth grade students at medium stratification level near Karlsruhe, Germany. Before starting the working phase with the multimedia application, the research subjects were allocated to two cohorts (2-D/stereoscope 3-D)

arbitrarily and filled in an issue-specific pretest concept map. During the working phase, the students were asked to mould a structural model of the nasal cavity consisting of modelling clay. They were also required to fill in a posttest concept map immediately after the working phase and to use both, concept map and structural model in an interview subsequent to the intervention, to explain anatomy and physiology of the nasal cavity .
The structural models revealed highly significant differences between the cohorts. Compared to the template`s proportions, the 3-D cohort models` proportions were more similar. Moreover, a higher number of shaped meatus of the nose was rated in the 3-D cohorts´ models, as well a more clearly configuration of shaped meatus was found. Furthermore, in the interview participants of the 3-D cohort succeeded better in integrating the structural model to explain the concepts and the propositions in their posttest concept maps. In addition, students succeeded better in referring their descriptive to depictive representations. In this case, stereoscopic 3-D seemed to be a useful tool to foster the appropriation of the presented biological topic.

102. A school garden as a location of health education: Green cheers you up
Carolin Retzlaff-Fürst
Health education is a major topic in (scholastic) biology classes. Health as a person's state is composed by physical, mental and social aspects (WHO 1946, Hurrelmann 2000) .
The presence of nature can have positive effects on all components of the (subjective) well-being of humans at all ages (Ulrich 1984; Health Council of the Netherlands 2004; Barton/Pretty 2010).
In the scholastic context or environment, gardens hold various functions as (special) places for the contact between humans and nature: They are areas for explorative learning, they provide manifold sources for interdisciplinary teaching, they are spots to generate skills and recovery and they are places for nutritional and environmental education (Blair 2009; Jäckel 2010). Generally, school gardens may take over a significant function in view of health education and wellness of children and adolescents .
As a consequence, practical work and / or any other activity in a school garden lets the place become a point for physical agitation, relaxation and stress reduction .
School garden classes and school garden practice in most of the cases are only held in the lower age groups of pupils (primary school). An analysis shall show that school gardens also could be employed for the health education in higher grades (11th and 12th grade). In the course of a pre-study, students (teacher students and / or prospective teachers) of the second semester were exemplarily interviewed in the educational garden of the University of Rostock about their subjective well-being. As a result, it was proved that garden activities have highly positive effects on self-esteem.

69. Pedagogical content knowledge of teacher students for promoting systems thinking (Symposium: Systems Thinking)

Frank Rosenkraenzer, Werner Riess, Elmar Stahl and Christian Hoersch

Current research on teacher knowledge distinguished 'pedagogical content knowledge' (PCK) as a special kind of teacher knowledge in addition to content knowledge (CK) and pedagogical knowledge (PK) (Shulman, 1986; Abell, 2011).

For teaching the complexity of a world getting more and more global and interconnect-ed, as well as knowing about problems and solving complex dynamic tasks, teachers, pre-teachers and teacher students have to be well skilled in 'pedagogical content knowledge' for teaching systems thinking in school .

The development of pedagogical content knowledge to promote systems thinking has not been addressed yet. Additionally, there are no research findings for PCK develop-ment opportunities to promote systems thinking (PCK SysTh). So our research group explored the effect of a different treatment in Science Education for teacher students promoting their PCK in teaching systems thinking

In a quasiexperimental pre/post-test survey with three experimental groups and one control group (N=108) joining student teachers studying biology and geography in uni-versities of education in Germany the effects of different treatments were analysed .

The results of this survey offer valuable clues to the correlation of aspects of content knowledge with aspects of pedagogical content knowledge for teaching systems think-ing. Furthermore, the results confirm their place in future science teaching education for promoting systems thinking.

16. Tacit relationships between biology and mathematics teachers content knowledge (CK) and their pedagogical content knowledge (PCK)

Ronit Rozenszajn and Anat Yarden

Content knowledge (CK) and pedagogical content knowledge (PCK) are considered as critical professional development resources for teachers, each requiring special attention during teacher training and classroom teaching practice. It has been shown that the distinction between CK and PCK is helpful in identifying the kinds of knowledge that play an important role in teachers' learning. Several studies examined the relationships between CK and PCK and their influence on teaching. Some studies suggest that enhanced CK may afford teachers a broader and a more varied repertoire of teaching strategies, while limited CK has been shown to be detrimental to PCK, limiting the scope of its development. Conversely, other studies showed that a broad CK in the discipline does not guarantee that teachers use it effectively in classroom practice. In order to better understand this controversial issue we investigated whether the tacit relationships between CK and PCK differ between teachers from different disciplines, particularly between those who are involved in the teaching of biology and mathematics in high school. We focused on the tacit relationships between CK and PCK using the repertory grid technique (RGT) which was specially designed for probing implicit tacit knowledge. Our study shows that while high-

school biology teachers tend to distinguish between CK and PCK, mathematics teachers tend to connect between CK and PCK. Therefore, we suggest that the discussion about the relationships between CK and PCK should first relate to the discipline in subject. CK may not be considered as an integral part of biology teachers' PCK, as suggested by Lee and Luft (2008), but can be considered as a separate entity, as suggested by Shulman (1986). In contrast, CK may be considered as an integral part of mathematics teachers' PCK, as suggested by Ball (2008).

113. BioDiv2Go - Using Geogames to foster biodiversity
Steffen Schaal, Anabel Haas, Armin Lude and Sonja Schaal
How biodiversity on a local scale is perceived and valued is part of an extensive debate in the community of educators. In fact, plant blindness and the loss of species knowledge increased in general in the last decades. Attitudes and knowledge towards biodiversity conservation can be influenced most fruitfully during the childhood and youth. The aim of the BioDiv2Go project is to create sensuous experiences and the appreciation of biodiversity using mobile technology. Therefore, three different types of geogames for experiental outdoor learning activities are developed and tested. Geogame I is open to everyone and focuses on the biodiversity at the doorstep, Geogame II is developed for visitors of German youth hostels in hotspot areas of biodiversity and Geogame III is intended as adaptable framework for educational staff at every youth hostel. The poster describes the multidisciplinary theoretical framework of the approach and derives the educational guidelines for the development of the three geogames.

73. Assessment of Students´ Biological Knowledge and Personal Traits when Beginning to Study Life Sciences at University – Instrument Development and First Results
Yvonne Schachtschneider, Vanessa Pfeiffer, Silvia Wenning and Angela Sandmann
Individual characteristics of first-year students are important predictors for university success. In public debate, it exist the prejudice of unfavorable cognitive and psychosocial profiles of teacher candidates. These suggestions accompany the beliefs of which some teachers are unlikely to succeed their work. But there is no current research to show differences and common grounds regarding the first-year students' characteristics in biology degree programs .
So this study is focused on measuring students' biological knowledge and personal traits when beginning to study life sciences. 194 students of 3 degree programs (preservice teacher education, medical biology and biology) answered 73 multiple-choice items of a new instrument developed to measure biological knowledge at university entry. Well-proven instruments to measure self-efficacy, academic self-concept and study interest completed data capture. For the knowledge test Rasch analyses showed an EAP/PV-reliability of 0.87 (Cronbach's Alpha α=0.88) and itemfits (MNSQ's) in the range of 0.85 and 1.22. First results indicate differences between the students of the particular degree programs. Students of the Medical Biology degree program achieved better results in the

knowledge test than students of all other degree programs. There are no differences between the prospective teachers and the students of the biology degree program. Within the students participating in a preservice teacher education degree program those scored higher who prepare to earn a degree that allows them to teach higher grades compared to their counterparts qualifying for lower grades only. Correlation analysis indicates that students´ test performance is associated with their academic self-concept .
These first results confirm the interdisciplinary findings for life science degree students. Next step of the project are data collections in fall 2013 and 2014. First-year students as well as students studying in their third semester will be tested to allow empirically-based statements to be made about the development of the surveyed variables over the course of the first academic year. Findings are to be applied by the University of Duisburg-Essen to improve the quality of biological academic studies within the first academic year.

66. Does Inquiry learning support long-term memory?
Sarah Schmid and Franz X. Bogner
The theory of Inquiry Based Science Education (IBSE) provides the base for the presented in-quiry lesson “The Hearing of Sound”. It is optimized for 10th graders and enables them to explore the topic of sound and hearing from an interdisciplinary perspective. The study followed a quasi-experimental design. The treatment group consisted of 267 students .
Their classes were visited with the inquiry material. The students then were given
A journal with background information described the related phenomena with a time course of 3 consecutive hours of hearing and sound. Students completed hands-on experiments, with material provided. Participants’ content knowledge on the subject was monitored four times: two weeks prior, at the day of the inquiry lesson, six and twelve weeks after the inquiry lesson .
We could prove that inquiry learning does indeed lead to long term memory. There was no sig-nificant difference in the knowledge level after six weeks (median=9) and after twelve weeks (median=9), T=3483,50, p>0.5, r= -0,01, showing that students kept the same amount of memory six weeks after and twelve weeks after the inquiry lesson. Furthermore, we show that inquiry lessons are useful for both gender, as well as for students with high and low pre-knowledge. Men (medianVTm=6) started with a significant higher level of pre-knowledge on the topic than wom-en (medianVTw=4), Ws=8515,5, p=<0,001 r=-0,27. When testing directly after the intervention, man (medianNTm=12) and women (medianBTw=12) reached the same knowledge level, Ws=10981, p>0,05, r=0,00. Conclusions for every day teaching in school, by using inquiry teaching more frequently will be discussed.

1. Factors influencing conceptual change when South African learners encounter evolution.
Debra Schroder and Edith Dempster
Evolution has been met with much debate, concern and conflict in its inclusion in the South African school curriculum. The aim of this investigation was to determine what conceptual

change occurs when learners are taught evolution and what factors influence this change looking in particular at learners' conceptual ecologies and the role that religious beliefs play. Conceptual change refers to a way of learning and is achieved when learners become dissatisfied with their existing understanding, and find the alternative explanation offered by the teacher fruitful, plausible and intelligible (Posner et al., 1982). Conceptual change may be impeded by learners' attitudes to the new conception and their conceptual ecologies (existing knowledge). A mixed methods approach was used because it obtains a fuller picture and provides a deeper understanding of a phenomenon by combining the strengths of qualitative and quantitative research. Learners were given a pre- and post-instruction survey and concept mapping task, and a sample of learners were interviewed post instruction. Results showed that learners made significant conceptual changes and that religious beliefs are the main contributing factor to learners' conceptual ecologies and the conceptual changes that occurred. An overall negative attitude was initially experienced from learners, but this developed into curiosity and interest. This study also highlights the notion that conceptual change theory is not sufficient in explaining how all learners learn evolution. Learners that experience cultural conflict follow various other learning paths explained by collateral learning. Collateral learning puts emphasis on the importance that learner cultures have in learning and highlights the importance of teaching for cultural border crossing.

75. Students' strategies in processing biological information from texts, pictures and text-picture-combinations

Julia Schwanewedel and Kathrin Klöpfel

Biological research papers are not only characterized by texts, but also by pictures, graphs and schematic diagrams. These external representations play an important role when scientists create, share and negotiate their knowledge (Anderson, 1999). The analysis of scientific textbooks or publications further shows that, in many cases representations are combined and modified to explain a certain scientific issue (diSessa, 2004). These characteristics of authentic scientific communication influence the presentation of new findings and current discussions in popular press and television, as well as the material students are confronted with when learning biology in school. Therefore, there is a common agreement on the importance of language that involves all kinds of representations that are used in constructing and communicating science for learners (Yore & Hand, 2010). Consequently, one would argue that the depth of biological knowledge does not only depend on the ability of a person to deal with biological texts, but also on his or her ability to deal with other representations such as diagrams, tables or images. For this reason, the ability to make meaning from different representations is considered a central part of discipline-specific literacy in biology and an important goal in biology education .

The paper reports the design and results of a study about students' strategies in processing information from external representations with biological content .

The presented research is based on the work of Ainsworth (1999), diSessa (2004) and Yore & Hand (2010) on multiple external representations (MERs) and their relevance in science education. Above that, the study takes the role of strategies into consideration when dealing with (single or multiple) external representations. Strategies learners apply when they try to understand a certain representation are seen as part of metacognition. The aim of the study is to describe and differentiate students' strategies to make meaning from different representations with biological content. The strategies are investigated in order to explore possibilities to support learners' abilities to deal with external representations in learning biology. The methodological approach involves an open questionnaire on strategies. 9th and 10th graders from different school types answer open questions on strategies after performing tasks in which they have to process information either from a text or a picture (diagram, table or image) or a combination of one text and one picture with biological content.

36. An Analysis of Attitudes and Values Regarding Genetic Counseling among Israeli Undergraduate Students

Merav Siani, Orit Ben-Zvi Assaraf and Moshe Barak

Genetic counseling has become a tool for preventing genetic diseases in western society. It deals with the risk of genetic diseases in families, considers the contribution of the genetic component, and finds ways to cope with and prevent a future problem. Cognitive and cultural barriers influence the public's decision making regarding genetic counseling. In addition, attitudes and values towards genetic counseling and towards genetic testing are influenced by religion. The main objective of this study is to shed light on the values and attitudes toward genetic issues (with an emphasis on genetic counseling) of undergraduate Israeli students, and how these are affected by the field they study, their religious affiliation and their gender. Three questionnaires, consisting of qualitative and quantitative parts, were distributed among 490 undergraduate students in institutions of higher education in Israel. The results show a significant correlation between the students' attitudes towards the detection of genetic diseases, their religious affiliation and the field they study. Religious students have far less trust in genetic tests, and students that study life sciences show more critical thinking towards genetic testing than those who do not study life sciences. The qualitative parts of the questionnaire were analyzed according to the framework described by Sadler & Zeidler (2004). The students' explanations were divided into 2 major categories: moral consequences (MC) and moral principles (MP). Students' answers to questions dealing with values towards genetic testing showed a correlation between the students' gender and their reasoning. The results of this research can serve as a basis for the development of culturally sensitive educational programs in genetics.

41. Using a serious game to encourage the design of innovative environmentally friendly agricultural systems

Jean Simonneaux, Fanny Leboucher and Marie-Angelina Magne

Farming should both reduce its negative externalities and adapt to climate change and variability and to economic and food-related challenges. Agricultural system vulnerability to climate change includes a contextual understanding of the problem situation and the integration of the social-ecological context. A serious game, the Forage Rummy, has been developed by researchers in agronomy in collaboration with professionals in livestock farming (farmers, advisors…) to help these latters to (re)-design forage systems more adapted to climate change and variability. Forage Rummy is a board game supported by a computerized simulator. Two main concepts are at stake in this serious game, ie agricultural system and its vulnerability and one main methodological principal, the participatory design. The aim of this paper is to analyze the transferability of this serious game to technical agricultural education which has the responsibility of training students to use more sustainable and more adaptable ways of production. We carried out an experiment on the use of Forage Rummy with a first year class on a higher technical diploma course. The game sequences were filmed and transcribed, the students filled out a questionnaire and several short interviews were conducted .

Players are led, collectively, to make virtual decisions, express their arguments, preferences, and lines of reasoning in order to explain the decisions they took and clarify the underlying goals. The students' use of this game has been analyzed considering 3 aspects: motivation, interaction and simulation. At the end of the session, students claimed they have a better understanding of what is meant by a farming complex system, which is a difficult objective to reach in agronomy education, they developed a common cooperative referential and improved their construction of complex livestock systems adapted to environmental constraints and integrating the uncertainties into their decisions.

5. The effects of a socially acute question on the evolution of the biological sciences curricula: the case of farm animal welfare

Laurence Simonneaux and Amélie Lipp

Farm animal welfare (FAW) has been the subject of heated debate in European societies since the 1960s, in particular, the acceptability of intensive (or industrial) livestock farming. The European Commission gave educating breeders and citizens a central role in the actions to improve FAW set out in its strategic plan 2012-2015. The concept of animal welfare is complex and interdisciplinary with disciplines originating in the biological sciences such as anatomy, physiology, neurosciences, ethology, animal husbandry but also other disciplines originating in humanities and social sciences such as ethics, economy…The knowledge is under construction and the controversies are acute both between and at the heart of each of the disciplines.

In France the BEPA (a national vocational certificate) in animal production qualifies the student to become a stockman and the Bac Pro CGEA (a vocational baccalaureate in farm

management) provides access to the position of breeding manager. These two qualifications carry increasingly large stakes within a political context in which the onus is on developing alternative breeding practices focusing much more on the question of animal welfare. Each curriculum has been regularly updated since 1985. Our research focuses on how the socially acute question of FAW has been progressively introduced (or not) into the curricula of these two vocational qualifications.

We firstly carried out a socio-epistemological study of animal welfare in order to identify the different aspects present in the process of knowledge construction. These results have enlightened our analysis of the evolution of animal welfare in the curricula of the vocational baccalaureate (Bac pro) and the national vocational certificate (BEPA.(

Our results reveal the progressive introduction, since 1992, of animal welfare into the curricula. At first, it was an educational/political question only present in the vocational section of the curricula (describing the occupations targeted by the qualifications) from 2008 onwards. Knowledge relating to animal welfare is progressively fleshed out as the curricula are updated but even today the concept remains largely simplified. It only concerns two vocational disciplines and the scientific knowledge is far from explicit. Indeed, the question is still presented in a neutral fashion; the controversial aspects are totally overlooked.

Thus, it is left up to the teacher to decide which scientific, social and vocational knowledge to teach in order to help students design ways of incorporating the notion of animal welfare into their breeding practices. The prescriptions do not incite teachers to clarify their ethical stance, which is nevertheless pivotal when teaching socially acute questions.

94. Characterizing the Development of Understanding the Human Body Systems in 10th Grade Biology Students

Zohar Snapir, Catherine Eberbach, Orit Ben Zvi Assaraf, Cindy Hmelo-Silver, Jaklin Tripto and Miriam Amit

Science education is increasingly focused on the instruction and learning of complex systems, such as the human body. In this paper, we examined the development of 10th grade biology students systems thinking in relation to their understanding of complex human body systems. To trace the learning trajectories of the students, we adapted the Component-Mechanism-Phenomena model. The tool for data collection in this study was the Repertory Grid technique that can help identify the level of system understanding of the students. As the first part of a three-year longitudinal study, we coded and analyzed the personal constructs of eighty-four 10th graders at the beginning and at the end of the school year. The constructs were coded into the level of components, mechanisms, or phenomena to track changes in student systems thinking. Our research show very little change in systems thinking amongst 10th grade biology students, consistent with prior research. However, there is a slight shift towards the CMP mechanism level, indicating that students are beginning to integrate more description of the component features that make such mechanisms possible. The data of the pre-test in this study were obtained from

students at the beginning of their high school biology curriculum, thus it is not surprising that students demonstrated novice understanding of human body systems. The more complex levels of the CMP categories, representing connections and interactions between components and mechanisms, are more consistent with an expert understanding of complex systems, which might emerge at later stages of the three-year study. We suggest that the learning process should explicitly emphasize the micro level, the mechanisms and the phenomena involved in the human body systems.

114. From "Hesitant" to "Environmental Leader" – The Influence of a Professional Development Course on Environmental Citizenship of Pre-School Teachers

Ornit Spektor-Levy, Yael Kesner-Baruch and Anat Abramovich

Environmental Education for Sustainability (EEfS) pertains to not only environmental problems, but also social justice, as well as cultural and political factors. The educational challenge is to enhance students' motivation, self-confidence, and willingness to act, to turn ecological literacy into action for environmental citizenship. To this end, educators should make essential efforts, starting in early educational frameworks. One way to succeed in implementing environmental citizenship at a young age is to enhance the kindergarten and pre-school teachers' environmental knowledge, awareness, and sense of responsibility .

To promote these issues, the Israeli National Teachers' Center for the Promotion of Mathematic, Scientific, and Technological Education in Pre-School developed a special Environmental Leadership Professional Development (PD) Course .

The main purpose of this course was for the participating teachers to develop leadership vision and a commitment to create a change in the community and in the natural environments. The course included 120 hours of academic and emotional empowerment, lectures and workshops focused on environmental citizenship, and leadership qualifications. The participants had to conduct an environmental venture with their young students (aged 3-5 years) in the community .

The main objective of this study was to examine how the Environmental Leadership PD course and the environmental venture affected the attitudes and behaviors of the pre-school teachers, their circles of influence, and their scientific literacy .

Twenty-three pre-school teachers took part in the PD course and agreed to participate in the study .

The study took the mixed method approach. The research tools included an Environmental Literacy, Attitudes and Behaviors Questionnaire; a portfolio documenting the venture's stages; and self-reflection. The questionnaire was administered to the participants at the beginning of the course

(pre–), at the end (post–), and one year later.

No significant differences were found in the participants' attitudes between pre– and post–questionnaires. However, a year later, they expressed greater faith in their ability to take action. According to the portfolio and self-reflections, we demonstrate how the participants

have changed from a “Hesitant” to an “Environmental Leader” who influenced pre-school children, their families, and extended circles in their community .
Evidence for personal or environmental leadership empowerment is demonstrated .
The environmental PD course described in this study may serve as a model to support pre-school teachers’ development into environmental leaders. These results are of great importance, since shifting from willingness to act toward actual activism is considered difficult to achieve.

6. Assessing students’ evaluation and judgment competence regarding climate change - concepts of biology and political education teachers
Benjamin Steffen and Corinna Hoessle
In consistency with an internationally enhanced tendency to integrate ethical issues into science education, Germany introduced the competence domain ‘evaluation and judgement competence’ as part of the national standards for science education in 2004. But, however, decision-making in the context of bioethics and environmental ethics constitutes a real challenge for both, biology teachers and students. A lack of assistance and teaching material on the part of the biology teachers renders the diagnosis of students’ performances regarding so-called socioscientific issues particularly difficult. In contrast to the subject biology, subjects like political education traditionally put more emphasis on the fostering of evaluation and judgement competence .
The study at hand uses a qualitative, interdisciplinary approach between biology and politics to focus on teachers’ diagnostic abilities concerning students’ evaluation and judgement competence. The socioscientific issue of global climate change is used as topical context. Following the research strategies of grounded theory, teachers’ concepts regarding diagnosis of students’ evaluation and judgement competence are outlined. Analysis of the first cases indicated that teachers of biology, rather than teachers of political education, assessed students’ evaluation and judgement competence intuitively and showed signs of insecurity regarding those issues. Reasons for the findings and possibilities to transfer insights from diagnosing political evaluation competence to diagnosing bioethical evaluation competence will be discussed.

147. Experimentation with gradually increased self-regulation: Is it beneficial for students’ motivation?
Cornelia Stiller, Stefan Hahn, Andreas Stockey and Matthias Wilde
To improve competences in scientific literacy we developed, tested and evaluated a competence oriented science course for the 11th grade at an experimental school in Germany. Scientific literacy is not only concerned with factual knowledge in natural sciences.. It describes a deeper understanding of nature of science and scientific inquiry (OECD, 2010; NRC, 1996). Experiments give students an opportunity to acquire factual knowledge and an understanding of the scientific way of thinking (Mayer, 2006). At the same time it allows them to answer scientific questions autonomously. The fulfillment of

the basic psychological need for autonomy is a relevant requirement for learning motivation (Deci & Ryan, 2002). The degree of self-regulation during experimentation should be adapted to the competencies of students (Mayer, 2006). The didactical approach of the course concept include the promotion of an understanding of basic concepts of biology, physics and chemistry and an understanding of scientific inquiry by realizing motivational impacts of self-determination throughout experimental work. The hypothetic-deductive way of scientific thinking is introduced in order to improve knowledge on scientific inquiry and nature of science. Every theoretical consideration of a scientific concept is combined with an experiment carried out by students. Within these experiments the grade of self-regulation is increased gradually. Previous results of the school year 2011/12 showed that the quality of motivation can be enhanced by the course. This leads to the actual research question: Does the gradually increased self-regulation support advantageous learning conditions and enhance the quality of motivation? To answer the research question students of the treatment group (students, who attended the science course) and the comparison group (students of other schools, who attended regular science lessons) had to answer a questionnaire in the beginning and the end of the school year 2012/13. The questionnaire includes (1) a questionnaire to conduct the quality of learning motivation (Müller, Hanfstingl & Andreitz, 2007) and (2) scales of perceived conditions of teaching (c.f. Frey, 2009). Furthermore there were two types of courses with backwards sequence of experiments at the experimental school. The students answered a questionnaire concerning situational interest, factual knowledge, motivation (Wilde, Bätz, Kovaleva & Urhahne, 2009) and perceived degree of self-regulation during experimentation at the beginning and at the end of four course units. A detailed analysis with a comparison of both alternative course concepts will show if the positive effects of the longitudinal study could be explained by the increasing degree of self-regulation.

64. Promoting systems thinking in the biology class - effectiveness of teacher training (Symposium: Systems thinking)

Stefan Streiling, Werner Riess and Christian Hoersch

Systems thinking is an essential key to handle complex natural scientific, economical and sociocultural questions, which is especially important in the field of “Education for Sustainable Development” (ESD). Prior studies have focused on directly promoting systems thinking in students. The present study goes one step further: it shows the effectiveness of a teacher training program in promoting students’ systems thinking.

95. How secondary teachers verbally relate the words gene, DNA and chromosome when teaching genetics

Karin Thörne and Niklas Gericke

This study investigates how biology teachers’ use and relate three of the most central words within genetics; gene, DNA and chromosome. Students are known to have problems

understanding these concepts and how they are related, but less is known about how teachers deal with this in actual teaching situations. The aim of this study is to contribute to the understanding of the underlying difficulties in genetics education by investigating the verbal communication in situ, as we see language to be at the very core of teaching and learning. Four secondary school teachers were observed and recorded during entire genetics teaching sequences, 45 lessons in total. All lessons were transcribed. All the occasions where the teachers mentioned the words gene, DNA and chromosome were identified, as well as occasions where the teachers made any type of semantic connection between at least two of these words. A linguistic analysis developed within the framework of systemic functional linguistics (SFL) was used to examine the semantic relations between the words of our focus. The analysis revealed that the teachers used the words frequently, but rarely being explicit about their internal relationships. When teachers did relate the words, they mostly related two of the words at a time. For example, gene was typically related to DNA as a part or a stretch of the DNA, DNA was often related to chromosome as something forming a chromosome. Even if these were typical ways of relating the words, other types of relations also occurred which resulted in inconsistencies. Gene and chromosomes were not related as frequently as the other combinations. We conclude that the overall sparse occurrence of explicit relations made by the teachers in their verbal communication in addition to inconsistencies when relating the words, could contribute to students difficulties previously described in literature. By the questions the students in our study ask even at the end of the teaching sequence, we can see how they struggle to understand how gene, DNA and chromosome are related. Our results suggest that these problems could be explained by how the subject is communicated in theclassroom.

136. How families make sense of biology at the zoo: the role of questions and questioning
Chagit Tishler, Orit Ben- Zvi Assaraf and Michael N. Fried

As repositories for a rich variety of living animals coming from a wealth of habitats, zoos are well placed to develop public understanding about the biological, ecological and environmental science pertaining to animals and biodiversity conservation. Families comprise more than half of the visitors to designed informal environments including zoos .

Families adapt strategies for family learning that have been practiced for many years, as they are accustomed to learning together. Within this “learning system,” the questioning process serves as a mediational strategy for family members to facilitate understanding. Questioning can be a way of assessing learner understanding and to provide linguistic thematic cues helping to move understanding forward. This paper is part of a boarder study that examines the interactions and learning processes that take place at exhibits on a zoo visit. The main object of the study is to characterize the questions of parents and children at the zoo; motivation and goals for asking the questions; and the kinds of scaffolding that such questioning implies .

The research site is the Tisch Family Zoological Gardens in Jerusalem (TFZ). 14 families were observed, the families were all subscribed members of the zoo. Along with the qualitative

approach, a mediated action approach was adopted in order to capture the complexity of the event taking place on the visit .
Findings suggest that, on the one hand, scaffolding questions are asked by parents to deepen knowledge and understanding about the natural world by connecting to epistemic knowledge the child is familiar with. The father in the following excerpt waits for answers and continuous questioning, leading to the general concept he's aiming at. On the other hand, questioning is not unidirectional: parents also rely on questions raised by the child .
Scaffolding questions are a strategy used frequently by parents at the zoo in order to teach a general principle and conceptual knowledge; however, the dependence on children's questions shows how scaffolding questions require a cooperative atmosphere. In addition, the findings reveal that this strategy is assisted by a strategy of connecting new knowledge to prior knowledge and that the prior knowledge is unique to each family.

18.Towards deep learning: The contribution of an innovative instructional model
Masha Tsaushu
The context of this study was a semester long undergraduate introductory biology course, for which we developed an alternative instructional model aiming to make student learning more meaningful .
Previous publications showed positive effect of the model on student outcomes in higher order thinking tasks. In this study, we investigated the factors that promoted deep learning.
The study was framed by the socioconstructivist theory and by the distinction between surface and deep learning. Based on these ideas we assumed that increased levels of interaction among students and between students and teaching staff would promote deep learning .
Our instructional model was based on the use of an interactive online tutorial, which enabled student self-learning of the informative data and thus cutting-off 70% of the lectures. In addition, each student participated in a small knowledge-building team, guided by a teaching-assistant (TA). The team studied one topic for four weeks and presented it in a "mini-conference" like event facilitated by the instructor .
Data were collected through observations of group and team meetings and through interviews with students and the instructor .
The interview data supported our interpretation of the observation data with respect to the course features that enhanced deep learning. Six major components were identified: the modification of content foci from descriptive information to more complex ideas and concepts, integration between topics, "wide scope" issues, and especially experiencing ways of "biological thinking"; the discussions among the team and with the TA; the inquiry activity, structured in the team work; constructing the team visual and oral presentation together; the mini-conference event; and the diverse modes of authentic assessment added to the multiple-choice final exam .
We suggest that even one topic which is studied in depth makes a difference and helps learners adopt a deep approach. Understanding complexity requires multiple opportunities

given to students for constructing their own understanding. The one-month group learning that enhanced our students' deep learning of one topic offers such opportunities. The learning habits and deep understanding that students developed in this intensive and multi-faceted learning experience were transferred to the learning of other course topics.

67. In search of a biology-specific pedagogy for initial teacher education in the 21st century

Alice Veldkamp, Paul van der Zande, Harrie Eijkelhof and Marie-Christine Knippels

In view of the development of skills that are essential to 21st-century citizens, attention is drawn to the necessary improvement of science education. At the same time, there is an impending shortage of highly qualified science teachers. Over the past decade, significant efforts have been made in different parts of the educational chain to improve the quality of biology education and its teachers. Only a fraction of these efforts have been aimed at improving the teaching of biology-specific pedagogy (BSP), although this is crucial for the development of highly qualified biology teachers. Therefore, a 5-year research project has been started, aiming at the development of a BSP framework for the 21st century, based on both empirical and literature studies. This framework will describe possible contents and corresponding methods for BSP in initial teacher education and its rationales.

There is a wide range of approaches to discipline-specific pedagogy. In this first study of the project, we explored the implications of three different prevailing trends in subject-specific pedagogical approaches on BSP. Together, they may offer a rich variety of useful insights applicable in BSP. In a literature study, useful insights from the selected approaches were gathered. Subsequently, the possible application of these insights in, for instance, educational manuals and textbooks has been analysed.

First results indicate that few insights of the analysed approaches have been implemented. A possible explanation is that researchers, curriculum developers and teacher educators seem to have limited awareness of the potential benefits of each other's work. These findings confirm the necessity to continue with an integrative approach to the development of a curriculum framework for BSP in initial teacher education. The framework will be used and extended in a study analysing the practice of biology teacher educators. Additionally, the framework may stimulate an international discussion on how to improve the teaching of future biology teachers, equipping them for the demands of the 21st-century society.

100. Beyond experimentation: observations and classifications in school science

Nicole Wellnitz and Jürgen Mayer

In science, systematic approaches are used to answer questions of interest and to explain phenomena from the natural world. Scientists use experiments as well as non-experimental approaches, such as observations and comparisons, to solve scientific problems. In other words, practising scientists employ a broad spectrum of valid inquiry methods to acquire new knowledge. Hence, scientific inquiry varies in its forms and ways. The mastery of this wide range of scientific methods and the discussion of their limits are central aspects of

scientific literacy. Yet, current science curricula and textbooks tend to overemphasize experiments as the scientific method, particularly focussing on the control and variation of variables. Students should, however, understand and be able to conduct different methods of inquiry to investigate scientific phenomena. In order to create an environment that supports students to understand different inquiry methods, it is thus important to analyse how methodological competence can be described, differentiated and assessed .

This paper presents the theoretical modelling and empirical validation of a structural model of methodological competence. First, we applied the process skills question, hypothesis, research design and data analysis to describe the inner structure of observing, classifying, and experimenting. To specify different levels of competence, any particular facet of inquiry method and process skill is hierarchically graduated to define five competence levels. For example, if students plan an experiment, their approach can be allocated to a specific level of competence. Second, we used the inner structure of each method to develop a measurement instrument based on multiple choice, short and open-ended items. These items (N = 132) were developed by teachers and researchers likewise and tested in the German project "Evaluation of the National Educational Standards for Natural Sciences at the Lower Secondary Level". Third, we removed any items that were not capable to fit the desired model empirically. Fourth, we utilized items that adequately represented the model to assess the methodological competence of 986 students (10th grade). Our findings provide evidence for the correlation between content-related task characteristics and task difficulty. Furthermore, item difficulty increases with the hierarchical levels of competence - except for the two lower levels. With the present model of competence it is possible to operationalize not only experimentation but further inquiry methods such as observing and classifying as results illustrate that students have difficulties to formulate hypotheses concerning all three methods. The inquiry method observation presents a major challenge for students in particular.

98. Students' Abilities in Decision-Making and the Influence of Socio-Scientific Contexts and Context-Person-Valences

Melanie Werner, Julia Schwanewedel and Jürgen Mayer

This paper reports the theoretical background, design and findings of a study about the influence of different contexts and context-person-valences on students' abilities in decision-making about socio-scientific issues .

Everyday decisions students have to make evoke ethically difficult questions and apart from biological content-knowledge students also need the ability to judge ethically. In order to improve these abilities in school decision-making was set as one of four competency-areas within the German National Educational Standards (NES) in science. In frame of the NES theoretically established and empirically firm competency-models to describe and monitor learners' competencies were developed. In the project ESNaS a competency-model of 'decision-making about SSI' was developed and operationalized in form of a task-based test which forms the basis for an empirical assessment of learners' competencies. Here,

decision-making is defined as learners' ability to identify, discuss and evaluate biological issues in different socio-scientific contexts (authors, 2004). Consequently, the specific contexts build the basis for decision-making processes and thereby set different conditions for these processes .

In frame of this study contexts were defined based on PISA 2006 (authors, 2006), authors(2006), authors(1998) and the NES (authors, 2004): Socio-scientific contexts that are relevant for decision-making consist of a biological content and a situation with ethical relevance. Four different contexts are distinguished: medical ethics, sustainability and environment, animal ethics and health .

When students involve with socio-scientific contexts, certain context-person-valences (e.g. interestingness, familiarity) arise. These valences are not in a context itself but arise when a person gets into contact with a certain context. Recent studies indicate that contexts or context-person-valences might influence students' abilities in decision-making (authors, 2004). The influences of these features have not been analyzed systematically so far and are in the main focus of this study .

The aim is to find out which context-person-valences are relevant when students deal with certain contexts and if and in how far students' abilities of decision-making depend on the respective contexts and the valences .

A task-based test was used to measure students' abilities in decision-making. A questionnaire was embedded after each task in order to analyze contexts and context-person-valences. Examples of the test-instrument as well as findings from the main study will be presented at the conference.

82. The consciousness of the Finnish and Swedish pre service teachers of the relationships of the concepts - species identification, biodiversity and sustainable development

Eija Yli-Panula, Christel Persson and Heini Pollari

There are difficulties in understanding the concepts related to environment and concepts related to sustainable development. The concept of the biodiversity is not well known and comprehension of BD as part of the sustainable development is difficult even for science students .

This study aimed to find what kind of conceptions do the pre service teachers have of the following concepts: species identification (SI), biodiversity (BD) and sustainable development (SD) and how well they understand the relationships between these three concepts ?

The data of this survey has been collected in southwestern Finland and southern Sweden in autumn 2011. The study subjects were asked to describe the three concepts SI, BD and SD and their relationships. Special emphasis was given to use drawings like mind maps, concept maps etc. The students were also asked to identify nine animal and nine plants species and were ranked in five categories according to their identification skills. The ranking of the students was used as a background variable. In inductive content based analysis students´ understanding of the three concepts and their relationships were

studied. The analyses were carried out in three groups: answers with text, with text and drawings or only drawings .
Firstly, the results show that the three concepts were connected to each other via students´ knowledge or understanding; e.g., the importance of conserving the nature and the understanding of its function as well as man´s interest in the nature and understanding of the basic biological phenomena were emphasized as important matters necessary for comprehending of the multifaceted concepts. Secondly, the concepts were connected to each other via man´s actions; e.g., when describing the relationships between the concepts man´s action was repeatedly mentioned. Man´s action and the way of living have an effect on conservation of the BD. Furthermore, people benefit from BD and take this into account when evaluating the importance of SD. Thirdly, the relationships of the concepts were difficult to understand by the students. In this case the connections between the concepts were not identified at all or the connections were not clearly described. Especially the relations between SI knowledge and BD or SD were difficult to understand. The success in species identification did not explain the students´ understanding.

93. Developing an interactive Method to map the Student Perspectives on Evolution
Jörg Zabel and Florian Koslowski

The paper presents work-in-progress, the development of a new diagnostic tool for student conceptions in the field of evolution theory. The core idea is to combine open-format and close-format data sampling in a way that reduces the time-consuming analysis of qualitative data considerably but still provides accurate picture of student conceptions. We report results from an in-depth usability study (N = 5, age 11 to 16) that revealed strengths and weaknesses of the procedure .
The focuses of the paper are (a) the description of this new type of two-step method and (b) its potential, seen both from a theoretical and an empirical point of view, the latter based on our test results so far .
The diagnostic tool consists of two subsequent phases: the first one is a writing assignment, where students are asked to explain an evolutionary phenomenon in a free text. After that, the text authors are asked to categorize 24 pre-formulated explanations as either 'contained' or 'not contained' in their text, or, in a third category, as 'not in my text but potentially true'. All items are based on the explanation categories by Zabel & Gropengiesser (2011). Three items were formulated for each of these categories. In the usability test, we assessed how accurately the text authors described their own text with the help of the items. To do so, we analysed their texts for explanations and evaluated their choice of items subsequently. Finally, all students were interviewed.
Our results show that the total number of explanation categories doubled in the close-format sampling, compared to the free text. However, only half of the items chosen as 'contained in my text' proved to be really in accordance with their text. The number of items categorized as 'not in my text, but potentially true' was roughly twice as high as in the 'contained'-category. Some item groups appeared quite homogenous to the students, but

others didn't. All students evaluated our diagnostic instrument as motivating and understandable. They mentioned that working with the pre-formulated explanations had opened their minds, and had made them start learning about evolution.
These first results indicate that this new way of mixed-method sampling may have some potential indeed, and that it is more sensible to the learner's conceptual 'ecology' (diSessa 2002), compared to traditional sampling methods. On the other hand, the big gap between our open- and close-format data on student conceptions remains an important challenge.

51. Developing Adapted Primary Literature modeling device for scientific writing in high-school

Galia Zer Kavod and Anat Yarden

In this study we wish to characterize the process of scientific inquiry-based writing of high-school biology majors and to develop a model for instruction of scientific writing using Adapted Primary Literature (APL).
APL is a text genre that retains the authentic characteristics of primary literature, adapted for science learning in high-school, and was suggested as an opportunity for experiencing how science is communicated by science practitioners. We hypothesize that APL can be used as a model of adequate scientific writing for high-school science students and along with the teachers' mediation and coaching could promote the socialization of high school students into the scientific community. As developing scientific writing skills has become a major educational goal in science education, our study is of outmost importance.
Design-based approach is applied in this study, towards developing an instructional device for scientific writing. In the first stage of the study, specific scientific writing difficulties were characterized using text analysis of inquiry-project reports of biology majors, class observations and interviews with teachers and students. Two main populations were examined in this study: 12th grade biology majors who study the elective APL-based curriculum (APL classes) and 12th grade biology majors who do not study this topic (Non-APL classes)
Our findings indicate that the weakest components of scientific writing among high school biology majors are: the scientific merit of the hypothesis, criticism, references to the literature and the justification of inquiry. In addition, no differences were observed between APL and non-APL classes, as students in the APL classes struggled with similar components of scientific writing as in the Non-APL classes. Furthermore, characterization of teachers' strategies for the instruction of scientific writing revealed that APL teachers indicate the analogy between APL and inquiry report in addition to strategies applied also by the Non-APL teachers.
Our findings indicate that reading and learning from APL is not sufficient for developing scientific writing skills. We are currently developing a web-based learning and teaching environment designed to address the specific writing difficulties characterized. This environment provides scaffolding of learning using APL and is designed to enable high

school students to construct the genre themselves and develop awareness of text qualities of inquiry reports.

Keynote speaker: Inquiry learning in biology education in Israel and its influence on other school subjects

Anat Zohar

In this lecture, I will discuss three inter-connected topics addressing inquiry learning in biology education: First, I will describe and analyze a system-wide reform designed to implement inquiry learning in biology education in Israel. Although sustainable pedagogical reforms are rare, this reform has been sustainable for more than 4 decades. The "secrets" of its long-term success will be analyzed, and current challenges will be described. The contribution of the late prof. Pinchas (Pini) Tamir to this reform will be highlighted. Second, influences of that reform on other school subjects will be noted. Third, in order to examine not only the scope of inquiry learning in biology but also its quality, I will move from a system-wide, macro level view to a micro-level view concerning deep process of learning and instruction. In this context I will focus on studies addressing the value of explicit teaching of metacognition in general, and meta-strategic knowledge of inquiry-related higher order thinking skills in particular. The benefits of metacognitive teaching to inquiry learning of low-achieving students will be discussed.

54. Learning about Ecological Systems with DynaLearn - A Qualitative Modeling Tool

Ruth Zuzovsky and David Mioduser.

This paper describes two evaluation studies that followed the development of a sophisticated computer tool that enables learners to learn by modeling complex phenomena. The studies aimed to evaluate the effect of the tool on the development of systems' worldview and systems' thinking skills of junior high school students' learning about complex ecological systems. Students were asked to represent these systems using concept maps and later to construct qualitative models, and run these to explore systems' dynamic aspects .

These two activities served, simultaneously, both pedagogical and evaluation aims. However, as the purpose of the two activities is different, they reveal different aspects of systems' thinking: The purpose of concept mapping is descriptive – it provides a detailed and faithful conceptual account of reality; the purpose of constructing models is explanatory as it aims to represent, parsimoniously, a segment of reality, to explore its possible behaviors, to choose the most plausible explanations for these behaviors, and to predict it under changing conditions .

The findings of this study provided us with a set of evaluation criteria and coding guidelines that allow to distinguish between levels of system thinking in students' learning products. As the modeling task progressed, a move from linear representation of the system structure to a hierarchical one, and then to a web-like configuration, occurred. The modeling activity attracted attention to processes occurring and to causal relationships that

explain the behavior of the system. It also allowed to distinguish between "explicit" causal relationships and hidden indirect relationships, enabling understanding of the emerging behavior of a system under changing conditions. Quantities (e.g., amounts, rates of change) that were ignored in concept maps were properly addressed in the models, allowing to capture dynamic aspects of a system when it adapts to changes in its environment.

Abstract of Symposium 2

Dirk Jan Boerwinkel and Marcus Grace (Symposium organizers)

Leading researchers in the field have submitted short papers on the subject uploaded at: "Symposium 2" for background reading prior to the symposium. Those abstract appear in an alphabetical order below.

We have listed the following main themes for discussion emerging from these papers:

A. What defines the scope of our research? There are many topics which are important in biology teaching but not necessarily part of our research. Where do we draw the line, for instance in studying health education or nature of science? Should all our research be linked to the learning of biological concepts or biological reasoning?

B. What is our focus? Should our research be based on and contributing to questions from the practice of biology teaching? Should we focus on the 'how questions' or should we pay more attention to research on normative questions about what we should teach and why we should teach this? Should we align our research with the big biology themes and if yes which are they? Or should we align our research along themes that are successfully studied in science education research?

C. What are our methods? Are we a social science with social science methods? Or is our research transdisciplinary and if so, what consequences does this have for our methods? What training do our researchers need?

D. How can we become more influential and effective? How can our research contribute more to science education research and the learning sciences? Should we be physically restructuring ERIDOB? (e.g. changing its name; more strongly promoting proceedings and papers).To what extent should our biology education research align with political agendas and normative influences? How can we share knowledge about vacancies for biology education researchers and opportunities/threats to relevant jobs and projects?

Our Double Helix - ERIDOB in the Face of the Two Strands of Biology Didaktik
Horst Bayrhuber

From the 1960s, the main focus of the work in Didaktik of Biology being carried out at universities was to develop and test novel approaches and new materials for teaching Biology in schools. This move to find a new way of teaching Biology (as well as Chemistry and Physics) stemmed from what we came to call the Sputnik Shock of 1957. Governments hoped that a modernized approach to the sciences in schools would be instrumental in keeping their country strong in the face of international competition - competition which they had begun to fear following the success of the Soviet Union in the space race. Against this background, institutes were set up to address the new demands on science education, such as the BSCS in Colorado Springs and the IPN at the University of Kiel.

The development and trialling of approaches and materials for use in schools was not, however, regarded as true *research* by the researchers in the sciences and other reference disciplines at universities. By the 1990s there was a real danger that Didaktik of Biology

would be banished from our universities, along with all the other Subject Matter Didaktiks. If academics in these fields were to face up to this challenge, they would now be required to engage in internationally recognized research. In the mid-1990s in Germany, this did indeed open a new, empirical chapter in Didaktik of Biology and the other natural sciences as well as mathematics. Recognition and opportunity came in the form of funding from DFG, the German Research Foundation, which provided the first grants for empirical research in science education, most notably in Didaktik of Biology.

An early initiative to support empirical research at European level came from the group which constituted itself as "European Researchers in Didaktik[1] of Biology" (ERIDOB). ERIDOB was founded with the aim of promoting empirical research in Didaktik of Biology in Europe - and in the process supporting Didaktik of Biology at universities across the continent. In accordance with this, ERIDOB conferences had from the beginning a clearly empirical focus. They were also affairs with relatively small numbers of participants; they had the character and feel of workshops. All the projects were to be discussed by all the participants. Younger colleagues, for whom empirical research was new ground, were to find support from more experienced researchers.

Thus we can see that the part played by the politics of academic disciplines cannot be ignored when we look back at the motivation for this swing towards the empirical in Didaktik of Biology.

1 Strengths and weaknesses of empirical research in Didaktik of Biology

Empirical research in Didaktik of Biology can in general be said to have considerable strengths, but also some weaknesses.

Empirical research referenced to a subject, let's say Biology or Physics, represents a real step forward in knowledge. The same cannot truly be said for the development and testing work in Subject Matter Didaktik. Empirical Research in the various specialized areas of a Subject Matter Didaktik builds on the work which has gone before and contributes to the development of theories. Testing a new teaching unit does allow us to evaluate how effective it will be in practice, but it cannot enlighten us as to whether a different approach might have led to better results. So in that sense we cannot describe it as progress in terms of knowledge. One development project rarely builds on another, and for that reason the wheel is likely to be reinvented on a fairly regular basis.

At the same time, however, the unassailable advantage of empirical research in our field is bought at a price. Empirical projects are bound to pursue a closely defined line of questioning about the teaching and learning of a necessarily restricted aspect of Biology.

[1]In the naming of the new group we have deliberately avoided "education" which includes a specific pedagogic literacy tradition. In place of it we used "Didaktik" in its comprehensive meaning in the European tradition. Consciously we spelled it twice with k to distinguish it from didactics, spelled twice with c, to avoid the connotation of methods, which used to be connected with "didactics", at least formerly.

This restriction is above all a matter of practicality; only relatively small projects can be successfully implemented within a manageable time frame. In university working groups of a typical size, broad-based research programs are doomed to failure. The requirement that a line of questioning be sharply focused is therefore on the one hand a great benefit with respect to the progression of knowledge and the development of theory. But this same feature is also a drawback: it becomes all too easy to lose sight of the diversity and complexity of teaching (objectives, contents, methods, media, interests, previous experience etc.) as well as the diversity and complexity of biosystems and biosciences in general.

Some empirical studies in Didaktik of Biology operate within the framework of a politically mandated concept of education and typically would address Scientific Literacy. One example here would be the analyses carried out in connection with PISA. This arrangement has the advantage that the empirical research it spawns will have strong links to practice and a relevance to educational policy. In the context of international comparative studies it will be easier for the work to feed into that of the wider international research community. A disadvantage of this proximity to educational policy, however, is that the research will be required to take on board whichever general goals of education currently prevail. And there is a danger that this can happen without adequate reflection. At all events, there is the danger that (supposedly) objective research findings will be obscured by normative influences and beset by the vagaries of educational policy.

Empirical findings in Didaktik of Biology draw on theories from the psychology of teaching and learning. This is a great advantage in that findings relating to the learning of a subject can be interpreted within the frameworks of these theories. But there is a danger that the analyses which then emerge under the banner of Didaktik of Biology, rather than serving to develop a theory of learning or teaching for Biology is actually serving to develop theory of learning in general, which sits more within the remit of Psychology. This is always the case when a project could just as well have been conducted by psychologists.

So my first point is that when we engage in subject-referenced empirical research, the advantages of knowledge enhancement and theory development are coupled with the drawbacks of normative constraints, a restriction in the scope of the scientific approach and a possible loss of reference to our subject itself. However, the indication of these problems should on no account be seen as a questioning of the great importance of subject-related research for ERIDOB.

2 Criteria for scientific modelling

Another question we should consider is whether a focus on empirical research leads us to neglect the pursuit of genuinely *scientific* tasks in the area of development. One of our paramount tasks in this area is the modelling of subject teaching taking into account the needs of the target group and the wider concept of what in German we call *Bildung* – personal development by (subject) learning. A frequent objection here, as I mentioned earlier, is that modelling is not a truly scientific pursuit; for modelling will be part of teaching preparation and as such is the task of any teacher. If we wish to counter this

objection, criteria for *scientific* modelling are needed. It would, I suggest, be an appropriate task for ERIDOB to systematically develop a catalogue of appropriate criteria. The following four criteria may serve as examples.

a) Critical reflection of the educational goals of school curricula

In many countries at present, Biology teaching is no longer defined by its input but rather by its outcomes, a development which has been decisively influenced by international comparative studies (such as TIMSS and PISA). This means that certain competences are to be nurtured and teaching content has to be conceived, presented and understood in relation to certain basic concepts. At stipulated points in a student's progression through the system, it will be ascertained whether these goals have been achieved. Teaching will, on the whole, tend to be focused on this assessment and is underpinned by a *functional* concept of literacy ("Bildung"). In the sciences, as I mentioned earlier, this is usually termed "Scientific Literacy".

Teachers cannot help but model their subject teaching on this concept, whereas a *scientific* approach would first of all engage in critical reflection of the overarching objective, for example in view of its consequences (in this case, teaching-to-the-test) or its ideological base (e.g. the maintenance of economic competitiveness or the utility principle). In addition, a scientific approach will confront the functional concept of education with a non-functional, for example, with the concept of non-utilitarian and self-determined personal development tempered by responsibility for the good of the wider community and with respect for individual human dignity. In this context, scientific Didaktik of Biology concerns itself with *alternative* anthropological conceptions and views of the world and aligns these with biological themes. It makes it transparent that there will always be an ideological background influencing modelling and thus the structure of teaching topics such as Ecology, Genetics and Evolution. *Scientific* modelling will show how pedagogical norms, anthropologies and views of the world – all of which teaching topics are assigned to – fit into a more general framework. At the same time it shows alternatives. It ensures that the goals, which young people are subject to in the educational process are transparent.

b) Reflection of the educational goals of academic disciplines

Specific educational objectives are constitutive of all scientific disciplines, whether they are reference disciplines for school curricula or not. Academic disciplines such as the biosciences are shaped, among other things, by communication and learning processes. Journal articles and lectures are vehicles to disseminate research goals, methods and results; reviews present and interpret the state of the art of knowledge in a particular area; university textbooks endow their subject with a particular structure. In each case, "learning objects" are modelled for the scientific community, each appropriate to its own group of addressees.

In the case of university textbooks, depending on the general objective with which they are written, topics from outside the discipline of their title may be included, for example theory of science, ethics, or political concepts (such as sustainable development). The contents and methods can also be selected with the graduates' future employers in mind. As a look

at a range of textbooks on the same topic will show, didaktikal modelling never leads to one single result; for the structure of a subject as represented by a university textbook is governed by educational objectives, in other words is determined by norms. *Scientific* Subject Matter Didaktik therefore has to point to the normative dimension of the publications through which a subject is communicated, in particular of those texts which are used to model the subject for the teaching of a particular target group. At the same time it needs to be explicit about the criteria of its own models.

c) Incorporation of theories of teaching and learning and of General Subject Matter Didaktik

When teachers are modelling new teaching units, their own memories of previously successful or less successful teaching will have a decisive influence on their decision-making. Academics of Subject Matter Didaktik will also consider general and subject-specific teaching and learning theories and findings of empirical studies obtained in the framework of such theories (cf. students preconceptions).

It would also be helpful – though this is thinking for the future – for them to be able to incorporate a generaltheory of Subject Matter Didaktik. This is a field very much under development at present (for example within the German Association for Fachdidaktik). It describes and substantiates the common features and the differentiating features of school subjects and shows how these each contribute to the students' own particular type of world encounter and self-encounter. These can be, for example, biological or scientific in nature, linguistic, artistic, or religious. Scientific Subject Matter Didaktik with its modelling supports learners in the integration of different approaches.

d) Evaluation of the effectiveness of modelling results

A fourth essential characteristic is of course the evaluation of results of scientific modelling, but I suggest no further elaboration is necessary here, within the context of ERIDOB.

These four criteria would form a basis of *scientific* modelling of a given subject. The list of course needs extending. In this connection regarding scientific approaches of what is called in English "Educational Design Research" could be helpful.

3 Subject Matter Didaktik – two fields of scientific enquiry

By now it should be clear that Didaktik of Biology, like all Subject Matter Didaktiks, has two constitutive strands (our "double helix"). One is the scientific modelling for teaching purposes of the fundamentals of the reference subject itself. The other is research into the processes involved and taking place when the subject is taught and learned. In this dyadic view, we can thus distinguish between "Subject Matter Didaktik as modelling science" and "Subject Matter Didaktik as subject-referenced teaching and learning research". Subject Matter Didaktik can thus be seen as two "knowledges", even two academic disciplines, whereby subject-referenced teaching and learning research could itself be seen alongside the biosciences as a reference discipline for the modelling strand of our activity. On the other hand modelling and evaluation of models respectively can generate research questions an hypotheses for subject-referenced teaching and learning research. Particularly when the results of subject-specific teaching and learning research are used to structure

teaching and learning processes, we should not lose sight of the fact that, like any reference discipline, it too comes with a normative dimension.

4 Consequences for ERIDOB

Returning to my opening question whether the focus on empirical research has possibly restricted the view of Biology of Didaktik, I believe that the answer to this has to be yes. Nevertheless, the presentation and discussion of research into the teaching and learning of Biology will continue to be *the* hallmark of ERIDOB. But I invite us to consider whether ERIDOB could now also regard the discussion of projects addressing *scientific* modelling for Biology teaching – and projects of this type have been represented here on occasions in the past (e. g. excellent projects on genetics) – as another part of its raison d'être in its own right. This would also be advantageous for our empirical research: the critical attitude of colleagues engaged in modelling science towards norms set by others could be helpful to Didaktik of Biology at the planning stage of empirical projects. It could guard against unreflected acceptance of extrinsic norms and thus guard against our discipline inadvertently serving as the uncritical handmaiden of (fickle) educational policy.

Current issues in biological education research: the case of Health Education

Graça S. Carvalho

Health education contributes to promote the feeling of responsibility of one's own and the others' health, enabling each one to perceive critically each actual situation in order to adopt the most appropriate and efficient behaviour. In this view, health education is an education for the life of persons and communities, contributing for the learning of how to improve not only one's own physical health but also the interpersonal relationships, leading to a general improvement of the collective well-being (Larue *et al.*, 2000). Health education is addressed to the person as a whole, mobilises knowledge, beliefs, social representations, behaviours, interactions with the physical and social environment. It is not to say what one must do, but rather to inform and to create the conditions for the person to acquire the competences for making (as much as possible) free choices for what he/she estimates it is healthier for him/her as well as for the others.

The nature of knowledge in health education is rather particular for several reasons. Firstly, health issues are usually acquired by traditional means, mainly following family practices, and empirical knowledge, having little scientific bases. Often this traditional knowledge is an epistemological obstacle (Bachelard, 1938; Astolfi *et al.,* 1997) to the acquisition of new scientific knowledge. Secondly, the source of the scientific knowledge to be transmitted in the field of health education is the biomedical knowledge, which, traditionally, is not devoted to the education perspective. Moreover, biomedical advices are usually formulated by reference to the current health problems, which often show up to be controversial with time (Sandrin-Berthon, 1997; Ewles & Simnett, 1999).Thirdly, scientific knowledge concerning health issues is often manipulated by commercial lobbies, mainly from the agriculture, food and pharmacological sectors, addressing health misinformation in products advertising and propaganda (Souccar & Robard, 2004).

Finally, health scientific knowledge is usually statistically validated at the population level – Epidemiology, Public Health – identifying determining factors (age, sex, lifestyle, environment) for each disease, aiming at establishing a causal link between these factors and the disease growth (Vetter & Matthews, 1999; Helman, 2000). What is true in terms of the probability of a disease growth in a population cannot be applied be for a person individually.Health education tends to be based on a topic approach, which means to work separately on issues like eating, safety, sexuality and relationships, substance use (smoking, tobacco, other drugs) bullying, etc. This topic approach has been criticised for several reasons: it can be *"problematic or ineffective as such approaches are sometimes based on assumptions relating to human behaviour, which are difficult to justify and not supported by evidence"* (IUHPE, 2008: 4); adding up the teaching sequences of such diversity of topics represents a huge amount of time, which imposes limits to the teacher's action who tend to transmit information only (Pizon, 2008). Therefore, instead of an exhaustive approach, topic by topic, a more effective approach is to develop children and young people's life skills and competencies, enabling them to consider the different health topics in the reality of social and environmental contexts of their lives (IUHPE, 2008).

Uniting themes, such as "learning how to take care of oneself and of the others" and "Preventing health risk behaviours", can cut across topics at a theoretical and pedagogical level.

For the prevention of risk behaviours, educators must have in mind all the above factors when implementing pedagogic activities on the prevention of risk behaviours in the classroom, which are associated to knowledge, attitudes and awareness. These three approaches are shown in Figure 1 and can be described as follows:

i) *To approach the problems caused by substance misuse – scientific knowledge*: implement pedagogical approaches on physical, psychological and social dimensions of the risk behaviours effects, based in scientific knowledge. Attention must be paid to ethical issues concerning potential effects of the approach regarding the stigmatisation of the smoker, the drunken or the drug-abuser.

ii) *To develop personal and social competencies – Attitudes*: developing self-esteem, stress management, risk management, conflict management. These competencies empower children and young people to make informed decisions, to make choices, to take actions and to develop positive attitudes facing health risks.

iii) *To approach the environmental context – awareness:* making children and young people aware of their specific familiar and close social environment to identify critical situations facilitating the risky behaviour. It implies developing critical thinking.

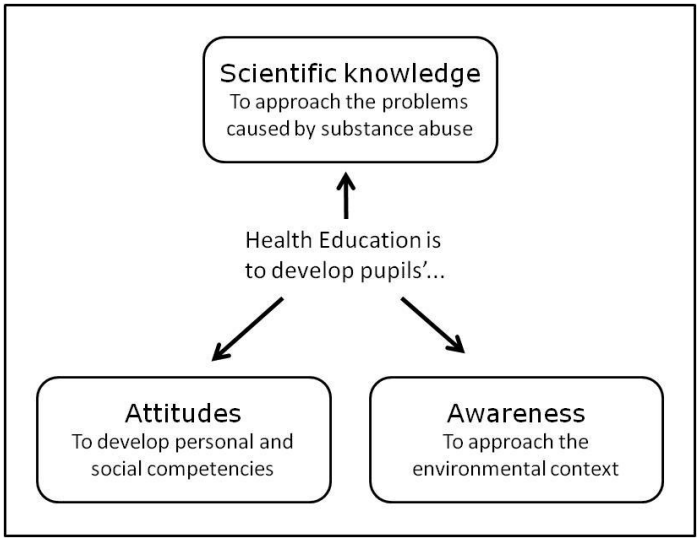

Figure 1. Dimensions to have into account in school activities for the prevention of health risk behaviours.

Defining teacher's role in health education is rather delicate for several reasons. Firstly, health and health education lies at the intersection between the private (pupils' family) and public domains (public health policies), related to behavioural issues which are determined culturally and to the most intimate of personal decisions. Furthermore, in health domains, recommendations change over the years given the extraordinary progress in knowledge and the construction of new scientific models as well as fashions governing what is considered to be moral and what is considered to be immoral. In addition, in the contemporary world, where the importance of appearance is becoming more pronounced, where many consider a perfect body and perfect health to be the ultimate aim, can it be hoped that schools will contribute to the promotion of a single healthy mode of living or a body cult?

In the field it is not easy to identify the school's mission in an environment marked by the power of the models transmitted by Medias. The position of teaching staff is, therefore, difficult to maintain. The first aim of teacher training in health promotion is then to help them to have a clear view of their mission and its ethical limits. Before giving them methodological tools, teacher training aims at helping them build their professional identity (Jourdan et al., 2008).

The way in which health promotion is organised and implemented in each country differs depending on the history, objectives and structures of that country's school system (Pommier & Jourdan, 2007). Developing research, affirming and reinforcing the work done in teachers' training in health education are major issues to promote teachers'

competencies for providing opportunities to children and young people to be more empowered about health and health risks as they grow up.

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On the issue of 'Research in Didactics of Biology'

Niklas Gericke and Christina Ottander

The question about the boundaries of *Research in Didactics of Biology* is perhaps not as well defined as one first might presuppose. The first definition that needs to be addressed is what constitutes the science of Biology. That question can intuitively be answered as knowledge about the living organisms of the earth and how they interact. Those boundaries are often perceived as not so difficult to distinguish although the boundaries of the science of Biology can be quite blurry in its interception with chemistry, engineering, informatics, psychology and social sciences. Since the 1950s the close interceptions between biology and chemistry regarding molecular sciences and biochemistry has been a question of debate in the aftermath of the molecular revolution within genetics. More lately, in the last decade, biology has merged with engineering and informatics in the area of biotechnology, which has led to the artificial engineering of genes and organisms. To be able to accomplish

the technological and scientific development the ability to interpret and store large amount of biological data has become a necessity. Most of these interceptions have been mostly in the realm of molecular sciences, but many of these areas are cross-disciplinary and could not be accomplished by biologists alone.

Another discussed area of the science of biology is in what way the human being should be included in the biological sciences. The anatomy and physiology is most often included, but then it most often relates to the medical sciences, or life sciences. Another dichotomy is also between “green” and “white” biology, the former relates to organisms and ecosystems in a macro scale, the latter to the molecular sciences. Sometimes “biology” is defined as “green” and “life sciences” as “white”, so where does that leave ERIDOB? We can also use the issue about the position of the “human” within sciences of biology as a point of reference when looking into questions related to behavior. When looking into animal behavior we are talking about ethology, which is clearly positioned within biology. However individual human behavior is related to psychiatry (medicine) and psychology (social science) not part of biology, although we have the socio-biology movement which aims at crossing this border and more closely relate human behavior to other species. Finally then we can extrapolate the issue about the position of humans within biology when we talk about how humans interact in groups creating social groups and culture. Then we definitely transcendent over into the realm of social sciences, although the border is being pushed back and forth depending on new findings within for example epigenetics.

However, to complicate this issue even further the human activity (in the realm of social science) influences the other living organisms by for example air pollution, mass extinction, global warming, changes of ecosystems etc. (in the realm of biology), which has led to that these issues are dealt with at an academic level both in biology (i.e. conservation biology) and social sciences. Also new academic disciplines has been established to meet these cross-disciplinary problems that has been created by humans, such as environmental sciences that draws from biology, earth sciences, chemistry as well as social sciences such as economy and politics. Hence the science of biology is not static, and biology didactics and biology didactic research has to constantly revise what to include in the subject of biology.

As can be seen in this short odyssey the disciplinary boundaries of biology within the academy and society have changed over time in a direction of more specialization, but in the same time towards more inter- and multi-disciplinary work. However the science of biology is not the same as the science of biology didactics or biology education. The same tendency can be seen also there. Biology didactics is about teaching and learning the science of biology from pre-school to tertiary education at the university level. Hence here we have an important dichotomy since the boundaries of biological science is determined by the scholars doing science, but the subject of biology in education is at all levels (except tertiary education) decided by political decisions which most often is manifested in steering documents such as curricula and syllabi. Moreover these steering documents define biology in many different ways depending on different aims with education. The overall aim most often focuses on either scientific literacy or more conventional

science knowledge. If scientific literacy is in focus the school subject of biology tends to be defined in a broader sense including aspects from social sciences, not included in the academic science of biology, such as: health issues, nutritious food, drugs, sex education, environmental issues and sustainability issues. If we in the *research of biology didactics* aim for including all research about the *school subject* of biology we will have to have a broad and inclusive definition of biology education. An important question to rise is if we want such an inclusive definition; including all biology education, or should it be limited somehow? If so, in what way?

Current reforms in science education emphasize teaching science for all, with the ultimate goal of developing scientific literacy. In this view, science instruction must go beyond teaching ”a body of knowledge”. There are three domains that are critical to develop scientific literacy: a body of knowledge; a set of methods/processes; and a way of knowing. Hence, teaching nature of science and scientific inquiry are important in school. The nature of science is inherent to many critical issues in science (and particularly biology) education. These include the evolution/creationism debate, the relationship between science and religion, and boundaries between science and non-science, as well as developing awareness of the impacts of science in society. But not all studies of scientific inquiry and NoS are relevant to discuss at the ERIDOB conference. We argue that it must be exemplified through biology teaching or by making comparisons between the different subjects of biology, chemistry and physics, to be valuable to discuss within the community of ERIDOB. In a similar way, teaching and learning on a general level are not relevant for the community either.

A consequence of the above mentioned fact that biology education is the result of political decisions, as well as pragmatic evolved teaching traditions, is that the definition of the school subject of biology varies over time, between countries and districts, school levels and even between teachers that enact the curricula differently. For example, biology does not exist as a school subject of its own in pre-school or primary school in several countries, where it instead is included in the general topic of science. If biological topics are taught thematically intertwined with other sciences could that then be included in ERIDOB? We argue that it should, as for example in socio-scientific issues or sustainability issues, but it is important that the biological part is in focus.

Another way to make “the biology” visible is to use overall didactical frameworks in the background that takes a clear position in the subject. Several of these describe the process of transformation of the academic discipline into a school subject which has been discussed previously in this paper, for example by Chevallard (1989) who coined *didactique transposition* in France, and Ongstad (2006) who talks about *omstilling* in Norway. These and other theories are good tools that could be used to make the difference between the academic science of biology and the school subject of biology more explicit. In that way it is for example possible to make clear what in biology education is biology and what relates to other domains, i.e. what questions relates to biological knowledge and what relates to values and political issues etc.

However we as a research community does not have to follow the boundaries set up by politicians and school administrators, we can define our own boundaries. Though we should not forget that our research is closely related to the practice, since we study the phenomena of teaching and learning biology, and we do so by using methodologies from social science. If we use other boundaries for our research, different from that of school biology, our relevance in society in general might be questioned.

Another area that definitely also is within the boundaries of "research in didactics of biology" is informal learning of biology.

We cannot find specific and detailed criteria for defining what constitutes biology didactic research due to the previous discussion, i.e. that the definition of school subject varies with time, country and school level. Therefore it would be hard to get an agreement about such common specific criteria. However we recognize that *if* there is an experience among participants that the relevance for biology education in the contributions to ERIDOB is too low, the conference will have problem since the motive for the establishment of the conference was the need for a fora for biology didactic research. If the contributions are not about biology education why do we then need this conference? One way to deal with this issue could be to demand for a specific description in each proposal to the *implications of biology education*, to define in what ways the contribution adds to our knowledge about biology education, as a consequence each author needs to define their own subject of biology and relate their work to it.

Research in biology education, both formal and informal, is taking place at several universities in Sweden. The research concerns all levels from preschool to tertiary education. Areas of interest comprise, for example, education for sustainable education, socio-scientific issues, argumentation, laboratory work, ecology, evolution, genetics, gene technology, and the human body. Examples of publications from the last years are presented in appendix 1.

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Appendix 1.

Examples of publications from Sweden within the area of "Didactics of biology".

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Lundström, M., Ekborg, M. & Ideland, M. (2012). To vaccinate or not to vaccinate: how teenagers justified their decision. *Cultural Studies of Science Education*, Vol 7, (1), p193-221
Manni, A., Sporre, K. & Ottander, C. (2013). Mapping what young students understand and value regarding sustainable development. *International Electronic Journal of Environmental Education, 3(1), 17-35.*
Olander, Clas (2013) Why am I learning evolution? Pointers towards enacted scientific literacy. *Journal of Biological Education*, Vol. 47 Issue 3, p175-181.
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Framing biology education research in science education research

María Pilar Jiménez-Aleixandre

Introduction: the place of biology education

What is the purpose of biology education research (BER)? Which research objectives are currently relevant? Which methods are appropriate to study them? Which are the criteria for producing high quality research about BE? Which insights have been gained from BER in the last decades? How does BER relate to the wider fields of science education and educational research? Which challenges are BE researchers facing? In particular: Which challenges are facing researchers in the ERIDOB community?

My argument in this paper is that, in order to enhance its quality and visibility, biology education research should be firmly framed within science education research. This claim is supported in the discussion about some of the questions raised above, in particular in the view, grounded on epistemology, considering science education and biology education as a part of Educational and Social Sciences, not of Natural Sciences.

First a reflection about ERIDOB name. When we first met in Kiel in 1996 the name "Didaktiks", soon changed to "Didactics", emphasized the European context, the name of our field (*Didáctica, Didactique, Didaktiks*) in most Indo-European languages, except English. We are aware of its association with lecturing and rote-memory learning. The price paid is, for instance, that a web search for "biology education research" yields, in the first six pages, or 60 results, only one related to ERIDOB, the index of the Braga meeting with "Biology Education" in its title. Researchers searching the web will find instead many results about SABER, Society for the Advancement of Biology Education Research (http://saber-biologyeducationresearch.wikispaces.com), "knowing" in Spanish, founded only four years ago by US scholars. I am not suggesting changing the name of ERIDOB, but perhaps to add Biology Education to it (for instance ERIDOB/BE), and certainly to the title of the conferences, now international.

A greater challenge than visibility on the web is our impact on the biology education community. Sadly, the research published in the ERIDOB proceedings seems almost invisible. I cannot remember seeing it cited in refereed journals, except for my own and some other ERIDOB members' papers. Besides increasing our impact by improving research and publishing in JCR journals, I suggest: first that ERIDOB needs a permanent webpage, where proceedings may be downloaded; second the need for interacting with other BE communities as SABER or BERG.

The goals and objectives of biology education research: looking at epistemology

I began by the last question but, turning to the first, I think that there is consensus about our goal: to increase knowledge about learning and teaching biology, in other words about students' and teachers' cognition and performances. For instance to design and test teaching strategies promoting students' engagement in scientific practices, such as argumentation or modelling (NGSS, 2013), or to generate and refine evidence-based learning progressions. This is connected to insights gained from research, as the need to use students' ideas as departing point of instruction, or the adoption of student-centred approaches, as inquiry-based and problem-based learning (Osborne & Dillon, 2008). These are instances first, of cutting-edge research objectives, and second, of educational implications, shared by the larger science education community.

I argue that the research objectives pursued by biology education research should be substantially the same as the ones sought by science education research. This claim is based on a conceptualization of biology education and science education as a field belonging to Educational Sciences, in other words to *Social Sciences*, although with interactions with science studies (history, philosophy, epistemology or sociology of science, here of biology), and with the disciplinary fields of science, here biology. Drawing on epistemology, the knowledge that biology education seeks to construct, its *aim*, using Chinn et al.'s (2011) terms for the components of epistemic cognition, is knowledge about how people learn biology (a social object), rather than knowledge related to organisms or biological systems (natural objects).

A criterion for high-quality research is the coherence between goals and methods. The methods –understood as underlying theoretical approaches about how to study something –, and particular methodologies coherent with our goals, related to people cognition and performances, are drawn from social sciences. They may be qualitative or quantitative, use approaches from sociology, ethnography or psychology, tools and schemes from philosophy or linguistics, content or discourse analysis or a range of others, all belonging to social sciences (Erickson, 1982).

This is not contradictory with the existence of biology education as a field exploring specific issues and themes. For instance, many educational issues are content-dependent; genetics or ecology have particular learning problems. On the other hand, teachers' PCK has unique features in each discipline, so we need to study PCK in biology. In a recent paper (Jiménez-Aleixandre, 2014), I have examined determinism and underdetermination in genetics, a question with deep implications for socio-scientific issues as racism. Although, certainly

there are also methodological differences among genetics, entomology, ecology or cell biology.

Conceptualizing biology education as a part of social sciences, even when explicitly accepted by all or almost all our community, may challenge the implicit professional identity of some researchers, who like to think of themselves as biologists studying education rather than as educators with a background in biology. Elsewhere I discussed this paradox for Spanish science teachers and educators, identifying their profession (in IDs) as chemists, biologists or physicists, rather than as teachers. The perceived higher status of natural sciences versus social sciences may be a reason.

Concluding remarks: the need for a stronger alignment with science education

If we, biology education researchers, belong to social sciences, to education, I suggest that three implications for ERIDOB researchers are, for instance: 1) a need for *aligning our research* (objectives, methods) with current research in science education, which is crucial for increasing publication in JCR journals; 2) including among our goals the *ambition to impact in the larger science education* community; 3) a need for *interdisciplinary cooperation with other social scientists* as psychologists or linguists.

About the *alignment*, there is room for improvement in ERIDOB: for instance a search of the selection of 2012 papers, in JBE and in the website, yielded no results about "practices" (although argumentation and modelling are represented), "learning progressions" or "metacognition", three cutting-edge research lines (there are others). This is quite different from the topics of papers in high-profile science education conferences from the same year (and even previous years), as ESERA or NARST. It is even different from research papers from European science educators with a background in Physics (e.g., a learning progression paper in JRST by Neumann et al. in 2013). A concern of the ERIDOB community is the relatively low publication of its research in major journals indexed in the SSCI-JCR, although publication in JBE is an improvement. I think that increasing it requires a stronger alignment with current concerns of science education research.

About the ambition to *impact in science education*, or even in education, it is related to the first suggestion. To achieve it, we need at least: a) to address issues that are relevant for the larger research community; b) to do so with methods that are considered rigorous and of quality by this community; and c) to publish our research in venues, journals and books, read by science education researchers, besides journals focusing on biology education. Some instances are the journals *Science Education, Journal of Research in Science Teaching*, both within the 10 first positions in JCR 2012; *International Journal of Science Education, Research in Science Education* (first quartile, Q1) or *Science & Education* (Q2). Evidence about impact are some highly-cited papers from our community (e.g., Duncan, Rogat & Yarden, 2009; Jiménez-Aleixandre et al., 2000; Zohar & Nemet, 2002). Although the content in all cases is genetics, they are cited by science educators from outside biology education, because the issues addressed transcend their disciplinary context. This parallels the beginnings of biology education research in the 80s, when we read and quoted physics

education papers about conceptual change, because of scarcity of papers on conceptual change in biology, a situation that we would like to see reversed or at least balanced.
About *interdisciplinary cooperation*, an outstanding example is the French science education research community (Erduran & Jiménez-Aleixandre, 2012). In other countries this may be less easy as science educators are based in disciplinary institutes.
In summary, this is an exciting time for education and science education and we, biology education researchers, need to fully participate in it.
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Research in Didactics of Biology – Current Problems and Future Perspectives

Dirk Krüger

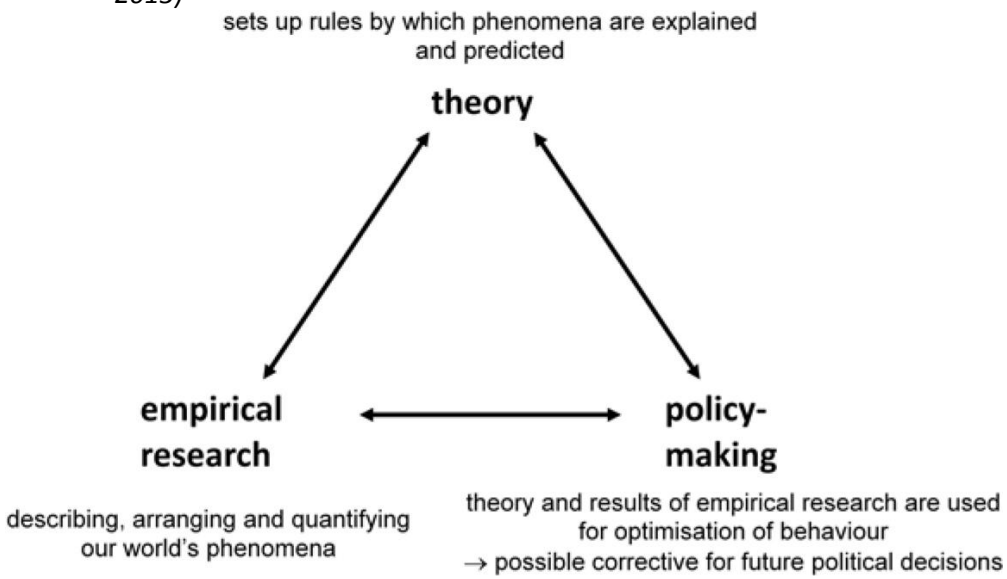
Dear ERIDOB,

here I address my view on Research in Didactics of Biology (RiDoB). I like to point out that this is my personal view and of course cannot be generalized as THE German perspective. My note will focus on three assumptions concerning the quality of RiDoB under the recognition of two questions: What is missing in RiDoB, what is there to do next?

General note: Three interactions that direct RiDoB.

Which research questions are raised for RiDoB depends on the corner of the triangle we start from (Figure 1). We try to describe phenomena of the world, we categorise and quantify, we develop theories to explain or predict these phenomena. Based on our results, we make suggestions to optimise teaching and learning of biology by influencing political decisions. In this triangle, a theory systematically links inductively or deductively won realizations of a knowledge range with one another, whereby single phenomena can be described, explained and predicted. Empirical research designates investigations, which are based on methodically controlled observations in the broadest sense – such as tests, interviews, questionnaires, experiments - and not on speculations. Theory and results of empirical research are used for optimisation of behaviour. This hopefully results in suggestions for future political decisions.

Figure 1: Interaction between theory, empirical research and policy-making (cf. Rost 2013)



I highlight some important research questions for the field of biology education. According to Rost (2013), educational questions concern seven groups:

1.	Existence	Is there such skill?
2.	Description	What is it like?
3.	Covariation	Does it correlate with … ?
4.	Structure	What is the internal structure of it?
5.	Prediction	Can it be forecasted?
6.	Cause and Explanation	How does it work? What causes it?
7.	Training and Optimisation	How can it be improved more efficiently?

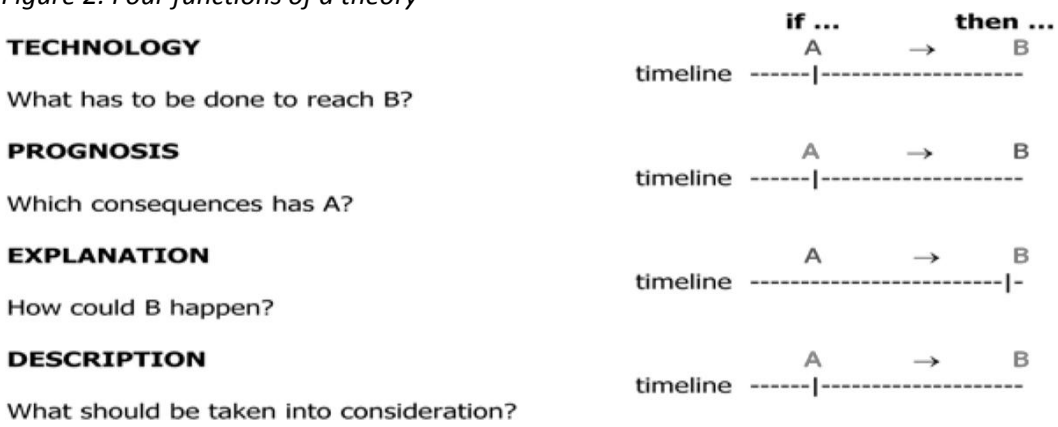
First assumption: RiDoB has to be based on theory!

We need a discussion about the meaning and use of theory. I will elaborate on this because there is no international consensus of which status theory will and should have at ERIDOB. Therefore, I like to highlight the relevance of theories in RiDoB: A theory is a general principle, which is set up in order to clarify a group of relations between events. A theory consists of statements about causes and effects of circumstances, is intersubjectively verifiable, is reproducible, is trustworthy because of results that have been confirmed repeatedly and from various directions, and it is, in principle, falsifiable. Only research which is based on theory creates the opportunity to enhance knowledge in didactics of biology.

Presentations lacking a theoretical underpinning run the risk to generalise results by chance (type I error). How should an audience member decide whether the presented results are relevant? We need criteria from the theory to determine the validity of every comparative or even superlative adjective in a presentation.

For the use of a theory you have to take four functions into consideration (Fig. 2). The green letters indicate the aim or observation, whereas the red letters symbolize what we would like to know. A theory is the helpful instrument to find information about this relationship and to develop your research. RiDoB should connect the hypotheses and the discussion to the theory in one of these senses. Finally, to avoid misunderstandings: The relation between theory and empirical research in biology education is not strictly deterministic (if A then always B), but rather probabilistic (if A then very likely B).

Figure 2: Four functions of a theory



Theory and results of empirical research are used for optimisation of behaviour → possible corrective for future political decisions

One way of strengthening German educational research was by publishing the *"theory book"* (Krüger & Vogt, 2007). 21 German researchers in didactics of biology described

theories they used in their research. I do not know whether this book was helpful in a direct way by the description or explanation of some theories, but in an informal sense this book was a starting point to give young researchers in our profession an idea what is essential and fundamental for RiDoB.

Second assumption: RiDoB needs standards for methodical approaches that are commonly known.

It is obvious that we need different methods to answers our research questions. To help researchers to handle the variety of approaches we published a *"method book"* (Krüger, Parchmann, Schecker, 2014). In this book 48 colleagues and researchers in didactics of biology, chemistry and physics described different approaches concerning the research design (e.g. action research, comparative studies, laboratory studies), qualitative data analysis (e.g. guided interviews, qualitative content analysis, group discussion, Delphi studies, narrative data, thinking aloud method), the evaluation of quantitative data (classical test theory: e.g. performance test, questionnaire, multi-level analysis) and the evaluation of quantitative data(probabilistic test theory: e.g. Rasch analysis, influence of task characteristics on task difficulty).

Without intending to say that there is a quantitative-qualitative split in RiDoB, we do have research groups working either predominantly qualitatively or quantitatively. Between these groups there is acceptance, but in some cases no real understanding of the different methodological approaches. This problem intensified with the application of probabilistic test theory. Perhaps ERIDOB could declare a minimal standard of methodical knowledge of research strategies. This may help to develop an appropriate scientific exchange. Like in biology, our research areas and methods become more complex and not everybody could learn all approaches while doing a doctorate. Those who understand different approaches have the benefit of choice.

Finally, one concern in many quantitative presentations is: To judge the relative impact, significance is not the right information. One has to take the effect-size into consideration.

Third assumption: ERIDOB needs a paper to declare standards and topics of RiDoB!

Finally, I try to open the discussion with some stimuli concerning the future development of ERIDOB to overcome some problems. I believe that a standard paper (additionally to the policy paper) will be a good approach. Here I will mention some topics that should be included in such a paper.

Theory-based empirical research

We should realise the value and use of theories. Furthermore, predominantly in quantitative research, we need the formulation of hypotheses. We must think about replication studies with samples in our countries to foster representativeness. We have to start meta-analyses and have to recognise the value of effect-size.

Consequences of the professionalization

With the arising demands for empirical standards (classical and probabilistic test theory) we need the cooperation with psychological staff. Probably ERIDOB should offer methods workshops and invite researchers of other disciplines, e.g. psychology.

Academic vacancies - improvement of an ERIDOB information system

Research groups are mostly missing postgraduate students. Instead of postgraduate students the staff usually includes a teacher with a high amount of teaching hours, who is often a brilliant teacher in the seminars but is nearly no help in filing an application for a third-party fund. We "*lose*" many PhD-students after finishing their thesis to schools. ERIDOB should develop a European communication forum to make transparent where staff is needed. Most German, Dutch and Scandinavian researchers are well prepared in the English language.

Questions to be answered in future

Some questions of self-determination and self-discovery for ERIDOB:

What is the singularity and identity of RiDoB? What are respected biology educational research areas by ERIDOB? What are examination objects that define RiDoB?

We have to define which topics are of interest for RiDoB! Are areas like philosophy of science or Nature of Science aspects of RiDoB or only of research in science education? Is research on interests, motivation or self-determination in biology classes RiDoB or research in psychology? Is the development of a test instrument RiDoB?
I suppose that the topic of a presentation that is accepted for presentation at ERIDOB is relevant for RiDoB. Reviewers of a submission for the proceedings regarding the same topic should be informed that a rejection could not follow the argumentation: The topic is not relevant for RiDoB.

For finding relevant topics I recommend to take national and international curricula (e.g. Australia: ACARA, 2012; Germany: KMK, 2005; UK: QCA, 2007; USA: NGSS Lead States, 2013) into consideration. I suggest three main topics concerning a standard paper for RiDoB: learning and teaching biology, learning and teaching about biology and learning and teaching doing biology (cf. Hodson 1992).

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The emergence and affiliations of current research in science education in France
Laurence Simonneaux and Jean Simonneaux

We can have no claim to completeness about the affiliations and orientations of current research in the didactics of science and technology in France. Science education was initially based on other fields in the humanities (developmental psychology, social psychology, sociology, anthropology, epistemology, philosophy, etc.). Science education was built on matters of disciplinary learning and sharing constructivist and socio-constructivist approaches.

Some research in science education (biology, physics and chemistry) and techniques has relied initially on didactics of mathematics, others are more inspired by social psychology (Giordan, Girault & Clement, 1994; Astolfi & Develay, 1989), others have opted to develop curriculum research (Lebeaume, 1999), while others are based on Bachelard's approach in developing the current problematization (Orange, 1997, Fleury & Fabre , 2005). We situate in this article these current aspects of research as well as the Socially Acute Questions (SAQ) trend and affiliations between the different current areas of research (see Fig.)

All current French approaches in didactics of biology use qualitative approaches.

In Théorie Anthropologique du Didactique (TAD) Chevallard (1985) within the school institution, individuals, teachers and students performed tasks relating to apprenticeship of knowledge. Any human action (such as actions of teachers and students) can be analyzed in a system called praxéologie (praxeology), which includes types of tasks associated with technology speech, justified by a theory. Transposition didactique (didactic transposition) is the activity of transforming an object of scholarly knowledge (produced at an academic levelinto an object of knowledge to be taught. There is external transposition where the noosphere decides the transformation of knowledge and practice for the curricula (formal or prescribed curriculum); and internal didactic transposition of knowledge involving the choices made by the teachers in effective educational content.

Sensevy, Mercier & Schubauer-Leoni (2000) developed another model of analysis of joint action between students and teacher (TACD) based on management of chrono-, meso-and topogenèses. They define ‘mésogenèse’, the genesis of the medium, as the development of a common system of meanings between the teacher and the students in didactic transactions which find their meaning. Chronogenesis Management is related to developing

knowledge objects on a time axis. Topogenesis (land management) is relative to the space occupied by the teachers and students throughout the teaching / learning process, and the sharing of responsibilities in the advance of knowledge.

The "problematization" the framework

This was developed by Orange (1997, 2000) and Fleury and Fabre (2005) under the problematization based on Bachelard and Popperian approaches. Scientific activity is not confined to describing reality or enumerating facts, it is an attempt to explain phenomena by the articulation between two registers: the models and the empirical facts considered. Appropriating such knowledge is developing the problem that knowledge answers, since it is in their relationship with the problems that scientific knowledge makes sense. It is therefore appropriate for students to engage with such knowledge and problems (e.g. through scientific debates in class) (Lhoste, Peterfalvi & Orange, 2007).

Analysis of social representations / designs.

This concerns analysis of students' (and teachers' and mediators')' conceptions (alternative knowledge, misconceptions, preconceptions, etc.). Derived from Piaget's constructivism and used in active teaching in Montessori and Decroly à Freinet. Students build their knowledge on their: " *déjà-là"* ('what's already in their mind') (Astolfi & Develay, 1989). Didacticians can refer to the field of social representations (Moscovici, 1974) when the knowledge is linked with social impacts. (Clement, 1994) refers to situational conceptions, ie related to a given context or model: K (knowledge), V (values) and P (social practices).

Curriculum Approach (Lebeaume 1999, 2010; Martinand, 2003; Coquidé, Lasson & Fortin, 2010), and Victor Lange (2006). The curricular approach is inspired by Anglo-Saxon approaches, it aims to analyze the aims and objectives of an educational program in the context of its implementation (sociological dimensions, political, educational and teaching). The purpose of the curriculum approach is to examine the consistency between the required tasks, the educational goals and the epistemological and social meanings.

Emergence of didactics of Socially Acute Questions (SAQ)

SAQ Didactics studies the process of teaching and learning in buoyant objects of controversy and debate in the scientific sphere, society and media, and therefore in the classroom (Legardez & Simonneaux, 2006).

This takes into account: The epistemological question in teaching, especially in the wake of the current Anglo-Saxon view of the Nature of Science (Lederman, 1992), emphasizing the social dimension of science - in connection with the current Science-Technology-Society (STS) approaches.

- Anglo-Saxon Socio-Scientific Issues (SSI) - (Sadler, Chambers & Zeidler, 2004; Zeidler, Walker, Ackett & Simmons, 2002). Current teaching of SSI has become one of the main trends in research in science education. This focuses on the social consequences of the applications of science and technology. There are similarities and differences between SSI and SAQ currents (Simonneaux, 2013).

The SAQ current analyses the socio-epistemological constructions of controversial knowledge (non-stabilized scientific knowledge, citizenship knowledge, professional

knowledge, whistle blowers knowledge, etc.), reasonings of students, uncertainties and risks involved in these questions, etc.

Conclusion

The structuring and restructuring of didactics around disciplines certainly continues, but it is also changing simultaneously to a cross-over with different didactics; and the didactics of experimental science has drawn heavily on the didactics of mathematics, whether the TAD or TACD. The emergence of SAQ is involved in this cross-over because these questions are interdisciplinary in nature. This is amplified with the emergence of "éducations à" especially in Education for Sustainable Development and Citizenship Education, or Education for Health in which research on the issues involves SAQ . The "éducations à" incorporates inter-disciplinary and multi-reference didactic questioning, which partially removes the disciplinary division (Simonneaux J & al, 2009).

Didactics remain defined by disciplinary inputs and have been legitimized in the form of "veneration of the discipline" (Chevallard, 2006). Now we are witnessing a paradigm change in education: an inventory of knowledge based on a pedagogy of exposure to knowledge, education is moving to a questioning of the world based on a pedagogy of inquiry (Ladage and Chevallard, 2010). Education research needs to be undertaken in this area as the discipline is an essential component of the learning paradigm.

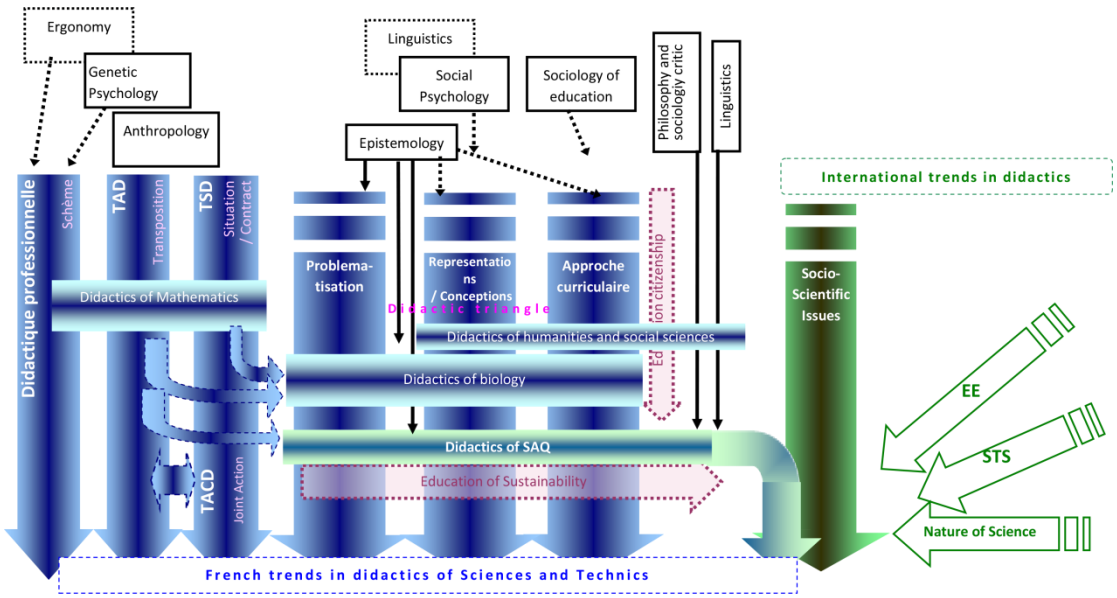

Schéma 1 : Emergence and filiation of the main trends in didactics of biology

The Future of Biology Education Research

Michael J Reiss

Biology education is a relatively young discipline and the field is so ripe for exploration that a researcher may feel like the boy in the parable who put his hand into a pitcher of figs and hazlenuts and grasped so many in his eagerness that he was unable to withdraw his hand and burst into tears.

However, there are other dangers in addition to biting off more than one can chew. One can flit from attractive topic to attractive topic (cf. the confusion effect in animal behaviour), failing to produce a solid and coherent body of work. Or one can be in awe of other research traditions, pushing one's own biology education research into a Procrustean bed.

Where to start?

In determining a programme for biology education research there are three main starting points: biology, education and research.

If one starts with biology, one starts, in an approach that derives from Hirst's (1965) 'forms of knowledge, with the distinctiveness of biology. For a start, biology sits within the natural sciences, which have a methodology that traditionally emphasises knowledge as objective, universal and amenable to rational inquiry (but see Feyerabend, 1993). Within the natural sciences biology, of course, is the study of life. In a sense we are spoilt for choice – there are some 10 million extant species and each of these, even on its own, can be researched in a myriad of ways. The most important biology research often proceeds by studying a range of species which then enables it to make conclusions or construct new models that are both widely applicable and also amenable to local variation (cf. Darwin, Mendel, the discoverers of the structure of DNA and such ecologists as E. O. Wilson). There is a lesson here for biology education research: we surely want to engage in fine-grained research that is true to the particularities of a particular situation; we also want to be able to extrapolate to broader horizons.

If one starts with education then one starts with what has sometimes been described not as a discipline but a field. Like medicine and engineering, education draws on a wide range of more fundamental disciplines to make its advances. This is an epistemological point about knowledge production in education. But there is another way of starting with education and that is to do so not from an epistemological standpoint but form a normative one. With John White I have argued that the aims of education are to equip each learner to lead a life that is personally flourishing and to help others to do so too (Reiss & White, 2013). If one accepts this approach, then biology education research can be seen as serving to contribute to such flourishing (indeed, 'others' would include non-humans).

I have deliberately started with biology and education because in my experience, certainly of supervising doctoral students, researchers, including biology education researchers, often start with research. We are expected to identify a gap in the literature, formulate research questions and then derive a methodology that allows us to address these research questions. However, while such an approach is efficacious in enabling findings to be

produced that add to the literature, and so are publishable, such findings are unduly constrained by the accidents of history – what has previously been researched – more than by what needs to be researched.

What is important?

About ten years ago I wrote a paper titled 'Teacher education and the new biology' (Reiss, 2006). In it I argued that recent years had seen a growth not only in biological knowledge but also, and more significantly for teacher education, in the types of knowledge manifested in biology. No longer, therefore, is it adequate for teachers to retain a Mertonian or a Popperian conception of science. Today's teachers of science need also to be able to help their students discuss bioethics and the societal implications of biology, even when these are controversial and contested. Moreover, practical work can no longer be confined to 'pure', 'safe' and 'confined' activities. These are increasingly rejected by students, validly, as boring or irrelevant. Instead, we need to help student undertake a range of activities that help them to develop criticality and the potential for action.

I think this holds even more strongly for biology education research. We need to keep in mind the purpose of our research (cf. Kincheloe & Steinberg, 2004). As Karl Marx said 'The point is not merely to understand the world but to change it'. In the UK, there has been more emphasis in recent years on the impact of scientific research, on knowledge transfer and on public engagement with research. Some commentators have understood this shift as the result of a naïve, politician-driven understand of knowledge production, and fear that it may lead to a narrowing of research and a consequent loss of quality. But another way of reading this new emphasis is to see it as a healthy desire for research to make a difference. Given how many of the world's major issues – climate change, species extinction, human well-being, our use of the environment, animal welfare – are ones where biology, education and research all play a key role, there is tremendous scope for the next generation of biology education research to be intellectually stimulating and also of great social impact.

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The nature of research in didactics of biology: a Dutch perspective

Arend Jan Waarlo

Introduction

The question about the essence of research in didactics of biology is comparable to the question 'What is life'? Biologists don't answer the latter question, instead they seek to describe and explain life phenomena. 'What is …?' is a philosophical question and as a researcher in didactics of biology I can express my view on this issue by reflecting on 40 years of personal work experience in didactics of biology. Didactics essentially studies both what is valuable and what is learnable to different ability and age groups in schools and how this should be aligned in the curriculum. *Valuable* refers to the normative task of didactics: the Why and What questions to be answered from three relevancy perspectives (biology, student and society). *Learnable* concerns the instrumental task: the How question.[2] The ultimate aim of research in didactics of biology is to contribute to understanding and improving contemporary teaching and learning of biology, which includes curriculum rethinking and empowering and facilitating teachers through research-informed pedagogies. Didactics shares with history and philosophy of biology the meta-perspective; from different angles they contribute to understanding the nature of biology. Let me start with some Dutch historical and contextual details.

Professionalization and scientification of teaching biology

Until the 1970s in the Netherlands you were either a born teacher or had to learn the art of teaching by just imitating your favourite teacher or your teaching supervisor. Over the past decades teacher education professionalized with a focus on reflective practice and developing a personal teaching style (self-development model; teachers as self-regulating learners). This professionalization tendency gradually got informed by two related research fields: teacher education research and research in didactics of school subjects. The latter field, starting in the 1980s, had and still has a strong focus on concept formation, development of subject specific attitudes and skills, and on curriculum issues. Unfortunately, these two research fields became more and more autonomous at the cost of synergy. In addition, researchers and teacher educators became separate groups which until recently contributed to the theory-practice gap. Ideally, a researcher in didactics of

[2] The Proceedings of the First Conference of ERIDOB in 1996 were entitled *What – Why – How? Research in Didaktik of Biology*. Both the title and the use of the German term 'Didaktik' reveal the difference between the continental and the Anglo-Saxon tradition. The Constitution of ESERA starts with the following preamble: 'Wherever the English phrase 'science education' appears in this document, it has a meaning equivalent to 'didactique des sciences' in French, 'Didaktiken der Naturwissenschaften' in German, 'Didáctica de las Ciencias' in Spanish, or the equivalent in other European languages (see Appendix)'. This was the outcome of a heated debate about the naming of the new association during the foundation of ESERA in 1995. The English 'didactics' has a connotation of imposing and thus is not equal to 'Didaktik'. In the mid-1980s Shulman coined the term 'Pedagogical Content Knowledge (PCK)' which does not fully cover the continental meaning of didactics either.

biology should have working experience as a teacher and as a teacher educator.[3] A promising development is that since 2007 Dutch teachers can apply for a part-time PhD position and combine work in school with qualifying as a researcher in didactics.[4]

Programmatic research in didactics of biology

The only Dutch chair in didactics of biology, hosted by Utrecht University, provided a strong impetus for research since the 1990s until it was recently cancelled due to budget cuts. Research in didactics of biology has now become almost fully dependent on external financing[5], which severely interferes with doing programmatic research. Let's focus on the heyday of Dutch research in didactics of biology. The research programme, which is now fading, focused on 1. transforming*domain-specific*[6] *meta-cognitions* into learning and teaching strategies (LTs) and on 2. *context-based biology education*. Systems thinking is central to life sciences and this was elaborated into yo-yo LT (genetics), modelling LT using multiple representations (cell biology, ecology) and molecular mechanistic reasoning LT (genomics). Next to systems thinking the perspective of form and function, i.e. taking a designer´s view, is central to biological (and technological) thinking, which was elaborated into learning by designing LT (immunology). Context-based LTs addressed the problem of transferring concepts between contexts (recontextualizing cellular respiration) and acquiring coherent understanding of biological concepts (cellular metabolism). Another strand in context-based research is genomics education for citizenship: socio-scientific learning. These studies share the *design research approach*, which has some common

[3]Cf. Van der Zande, P.A.M. (2011). *Learners in dialogue. Teacher Expertise and Learning in the Context of Genetic Testing.* Utrecht: Utrecht University (PhD thesis). In this research project research in didactics of biology and teacher education research were integrated. The researcher is an experienced biology teacher and teacher educator which is the best guarantee for implementation of research findings in practice.

[4] Reasons to start this programme were facilitating the implementation of context-based science education and to provide career opportunities for teachers.

[5] It's true that external funding is available but rather for curriculum development and implementation than for research.

[6] Research in didactics can be pragmatically demarcated by its focus on the domain of life sciences and the corresponding school subject. Subject specific concepts and scientific ways of thinking and acting are central. Subject knowledge is crucial in developing skills and attitudes. In addition, applications and implications of life sciences co-define the domain of research in didactics, mindful to situated learning in contexts like health, environment and agriculture. Since the late 1980s we gradually extended the field of didactics of biology to informal learning settings and started education of health and environmental education professionals. With the introduction of the bachelor-master system at the beginning of the 21st century we also added science communication, of which health and environmental education became part of. Due to budget cuts didactics of biology was forced to narrow down its scope, i.e., back to the core business of teacher education and school biology. Our pragmatic demarcation is still problematic. The sciences and technologies are converging. For example, synthetic biology, the engineering approach to biology, builds on life sciences, engineering and informatics.

ground with the German didactic reconstruction approach. In design research designing, studying, optimizing and reflecting/theorizing are interwoven. Case studies, using multi-method triangulation, are an important component of design research. Design research, although small-scale, has turned out to be quite time-consuming to get familiar with, to be difficult to publish and its theoretical output is modest and debatable.[7] On the other hand, design research provides theory-based and empirically tested educational designs for use in classroom and teacher training. The practical and theoretical outcomes are communicated through a website for teacher educators so as to promote the implementation of research findings into teacher education.[8] In addition, through participation of researchers in curriculum projects, syllabus review committees and examination boards, research findings may affect classroom practice after some time.

Organizational context of research as success factor

A new and valuable experience in the last decade was the participation in genomics-related education and communication activities, supported by grants from the *Centre for Society and Genomics* and the *Cancer Genomics Centre*, both genomics centres of the *Netherlands Genomics Initiative (NGI) / Netherlands Organisation for Scientific Research (NWO)*. We started with developing and implementing mobile DNA labs, followed by rethinking science curricula in the genomics era and concluded with international consensus building on genetics literacy needed by a 21st century citizen. The DNA labs were successful in providing new science content and skills in different application contexts, but underperformed in discussing the social and moral implications. In response to that more emphasis was put on techno-scientific citizenship education and informed decision-making (socio-scientific issues-based education). Many science teachers lack the support and confidence to address value-laden issues in their classrooms, so we also started research and in-service education to empower and facilitate them. Another research project focused on connecting molecular knowledge to phenomena at the higher level of cells, organs and organisms; a learning trajectory based on molecular-mechanistic reasoning was designed and tested. Unfortunately, *NGI* ended in 2013. Being part of the national multidisciplinary genomics network enabled us to learn a lot from genomics, humanities and social science researchers and from science communicators which was inspiring and helpful in updating biology education in schools.[9]

Nature of research in didactics of biology

[7] Boersma, K.Th. &Waarlo, A.J. (2009). On the theoretical input and output of 'design research' in biology education. In Hammann, M., Waarlo, A.J. &Boersma, K., *The Nature of Research in Biological Education. Old and New Perspectives on Theoretical and Methodological Issues*.ERIDOB Conference 2008. Utrecht: CD-β Press, FIsme-series on Research in Science Education, No. 60.

[8] See www.ecent.nl (in Dutch).

[9] CSG Next 2008-2013: Harvesting results & Preparing for the future http://www.society-lifesciences.nl/fileadmin/user_upload/docs/Publicaties_PDFs/Rapporten/CSG-next_2008-2013_web.pdf

Didactics of biology is *transdisciplinary* in nature, meaning that multiple academic disciplines contribute to it as well as practitioners with their practice knowledge and expertise. Delivering disciplines are history and philosophy of life sciences, pedagogical and educational sciences, communication sciences, and science and technology studies, including bioethics. It could partly also be characterized as *translational research*. In the genomics network findings from multidisciplinary basic research were made useful for practical applications so as to improve biology education (cf. translational medicine: from bench to bedside). Doing research is an effective way of having a *lasting or sustainable reflective conversation* on the what, why and how of teaching and learning biology informed by theoretical notions and empirical data and thus challenging stubborn beliefs. Developing a *common language* among members of the ERIDOB community will be important to facilitate effective communication. What struck me over the years, is that my expertise is rather embodied and 'emminded' than available in an *external knowledge base*. In my supervising or consulting activities, relevant expertise is activated that enables tailor-made comments. However, novices in the field have an urgent need for an appropriate and comprehensive textbook, which we cannot offer them yet. Up to now we refer to articles or book chapters in readers.[10] Gradually, an *integrated practice-oriented discipline of its own* should emerge characterized by autonomous, domain specific theory development on learning and teaching biology and by an eclectic set of appropriate research methods. Although the extent of research has increased considerably since ERIDOB was established, re-inventing the wheel is quite common and *domain-specific knowledge accumulation*, the aim of doing research, is still modest. The research culture of 'publish or perish' might account for paying insufficient attention to valuable publications of the past decades. *Gradual research-informed improvement* rather than hypes and hopes presented as renewal or change of biology education should be our mission.

Final remark

As to the Dutch situation of research in didactics of biology the warning slogan in advertisements of investment funds seems applicable: 'Results achieved in the past are no guarantee for the future'. Although we were meanwhile successful in acquiring two EU projects, PARRISE and SYNENERGENE respectively, these projects are not research-oriented and bring along much administrative workload. Our tenured staff has been reduced substantially, the only Dutch chair in didactics of biology has been cancelled and the changing research funding regime undermines programmatic research. Sharing and learning from threats and opportunities of national policies and strategies concerning research in didactics of biology in the ERIDOB research community is needed more than ever.

[10] A Delphi study amongst ERIDOB participants could be helpful in reaching consensus on key publications in our field to be included in a research knowledge base for graduate and PhD students.

The meaning of the term "Research in Didactics of Biology"

Anat Yarden and Michal Zion

Towards the 10th conference of ERIDOB we were asked to define the term "Research in Didactics of Biology" and to highlight questions that should be addressed in this research area. We attempt to provide answers to those two tasks, from the Israeli perspective, below.

Defining the term "Research in Didactics of Biology"

We initiated our thinking about the definition of the term "Research in Didactics of Biology" with an examination of the current ERIDOB documents: the ERIDOB policy paper and the call for proposals. A careful examination of the ERIDOB policy paper reveals that the term "Research in Didactics of Biology" was not defined since the ERIDOB organization was established 20 years ago in Kiel, Germany. An examination of the current ERIDOB strands, that are listed in the recent ERIDOB calls for papers (from 2010, 2012 and 2014), does not reveal the meaning of this term either, as the majority of the strands are general and not specific for research in biology didactics (Table 1). It appears that only strands 7 and 8 specify specific content, namely "Environmental education and Biology education" and "Health education and Biology education", while all the other strands are general to science education research and do not specify specifically any biological content. Thus, we believe that raising this question in this symposium is timely.

Table 1: Current ERIDOB Strands

1. Student conceptions and conceptual change
2. Student interest and motivation
3. Student values, attitudes and decision-making
4. Student reasoning, scientific thinking and argumentation
5. Teaching: teaching strategies, teaching environments
6. Teaching and learning with educational technology
7. Environmental education and Biology education
8. Health education and Biology education
9. Social, cultural and gender issues
10. Practical work and field work
11. Research methods and theoretical issues concerning research in Biology education

The essence of research in biology didactics obviously stems from the actual teaching and learning of biology in formal and informal contexts. It relies on every nation's educational frameworks and opportunities that are available for the teaching and learning of biology. We found the framework for K-12 science education that was recently published in the US (National Research Council [NRC], 2012), as suitable for the general framework of the

formal biology curriculum in our country, and we believe it is probably suitable for the syllabi in other countries as well. The framework is built around three major dimensions: core ideas, crosscutting concepts, and scientific practices. If we take as an example the curriculum for high school biology in Israel (10^{th}-12^{th} grades, 16-18 years old), it includes: i) core ideas in biology that are expressed in three obligatory core topics (homeostasis in the human body, the living cell, and ecology) and in a few elective topics (i.e., inheritance, reproduction); ii) eight crosscutting concepts, or main principles that are emphasized in every topic studied (i.e., homeostasis, structure-function relationships, evolution, organization of biological systems); and iii) practices (i.e., asking questions, planning and carrying out investigations, analyzing and interpreting data, constructing explanations, communicating information), which are expressed in an inquiry project carried out by the students, in laboratory experiments, in papers students are requested to read, and throughout the learning of the various core ideas. The three dimensions are embedded one within the others in such a way that learners are engaged with the core topics, the crosscutting concepts and the practices simultaneously (Israeli Ministry of Education, 2011). Accordingly, we see research in biology didactics as focusing on each of those three dimensions and on the integration between the three with the aim of promoting biology education. This is carried out by examining all facets of the teaching and learning of biology, including the learners, the teachers and the settings in which they both act. Due to various queries that were raised in the recent ERIDOB 2012 conference in Berlin we would like to emphasize that we believe research that is focused only on the practices and / or on the crosscutting concepts while learning and teaching other contents than biology cannot be considered as research in biology didactics.

We hereby suggest modifying the ERIDOB strands to reflect the way biology is taught and learned in the field, while putting more emphasis on the biological aspects. We based our suggestion on the strands of the National Association of Research in Science Teaching (NARST) with adaptations to our field (Table 2).

The following main modifications were incorporated into the newly suggested strands:

1. The newly suggested strands do not include strands 7 and 8 that are included in the current ERIDOB strands (Table 1). The reason for that is that we suggest that the related fields that are more interdisciplinary in nature, such as environmental education or health education, will be integrated within the other strands and not stand out independently of the other strands. It is not that we think that those strands should not be represented in ERIDOB, on the contrary. Current research in biological sciences is interdisciplinary in nature and this should be reflected in the educational programs and educational research. However, we suggest allowing those strands to be represented along with the other topics.
2. The previous strands 1-4 were regrouped and are not represented in the newly suggested strands 1 and 2, which are focused on various aspects of the leaning of biology.

3. The previous strand 5 is represented now in the newly suggested strands 2 and 3, which are focused on learning biology (strand 2) and on teaching biology (strand 3).

Table 2: Suggested ERIDOB Strands

1. Biology learning, understanding and conceptual change
   How students learn biology for understanding and conceptual change, students reasoning, scientific thinking and argumentation
2. Biology learning: contexts, characteristics and interactions
   Learning environments, teacher-student and student-student interactions, factors related to and/or affecting the learning of biology including interest and motivation to learn biology
3. Biology teaching: characteristics and strategies
   Biology teacher cognition, content knowledge, pedagogical knowledge, pedagogical content knowledge, instructional materials and strategies
4. Biology learning in informal contexts
   Biology learning and teaching in museums, outdoor settings, community programs, communications media and after-school programs
5. Biology teacher education
   Pre-service and in-service professional development of biology teachers, pre-service and in-service biology teacher education programs and policy, continuing professional development of biology teachers
6. Biology curriculum, evaluation, and assessment
   Biology curriculum development, change, implementation, dissemination and evaluation, including alternative forms of assessment of teaching and learning of biology
7. Cultural, social and gender issues
   Equity and diversity issues, sociocultural, bioethical, multicultural, bilingual, racial/ethnic, gender equity studies related to biology education
8. Teaching and learning biology with educational technology
   Computers, interactive multimedia, video and other technologies used for biology education
9. History, Philosophy, and Sociology of Biology
   Historical, philosophical and social issues related to biology education

4. The newly suggested strand 3 is also focusing on teachers' knowledge, i.e. pedagogical content knowledge, which was missing from the previous strands and is extensively discussed in the recent ERIDOB conferences.
5. The previous strands 10 and 11 were eliminated as they are represented in the other strands, and also since no submissions to those strands were accepted in the recent ERIDOB conferences.

We suggest putting the newly suggested strands up for discussion among the ERIDOB members and reach a consensus on a new list of strands representing our community research work in the field of "Research in Biology Didactics" for future ERIDOB conferences.

What research questions should be addressed in didactics of biology?

We believe that the foundations for research into biology didactics consist of two intertwined elements: the content element and the scientific reasoning element. Research into content alone would be no more than biology research; research into science reasoning alone would be general science education research. Accordingly, research in biology didactics should incorporate a biological element with a scientific reasoning element. Figure 1 shows that each element (content and scientific reasoning) includes sub-components. Biology didactics research offers a variety of interesting and creative connections between these sub-components and others being developed in the fields of science and of education. For example, research into the connections between:

- Understanding the nature of science and teaching the theory of evolution
- Developing scientific literacy by reading primary literature in genetics supported by ICT
- Developing critical thinking and systems thinking by doing open inquiry on plant hormones
- Professional development of biology teachers experiencing open inquiry themselves, on the subject of homeostasis in prokaryotes
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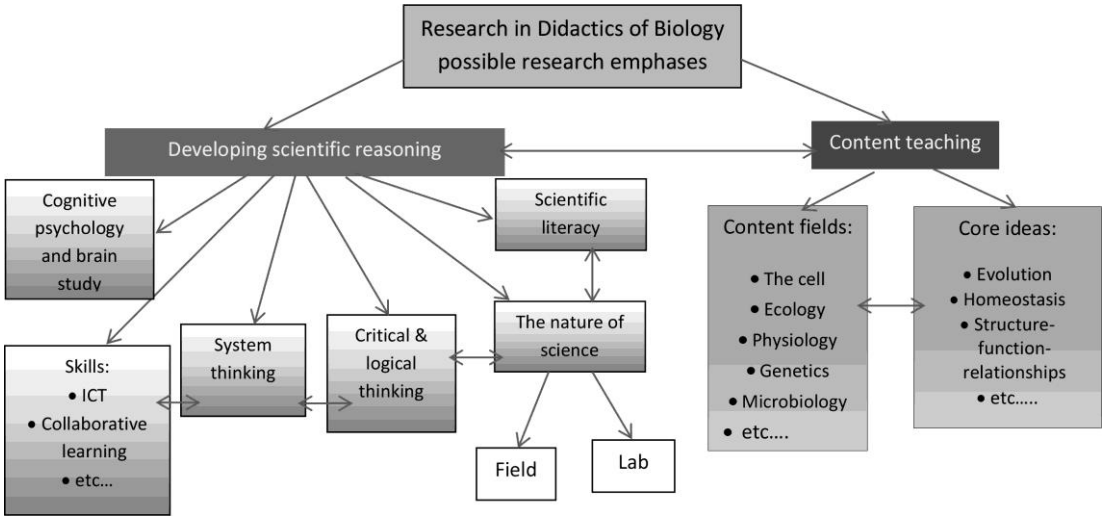

Figure 1: Emphases of Research in Didactics of Biology

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"Biology Education Research" or "Biology Didactics": thoughts concerning the constitution of a distinct domain of educational research

Vassiliki Zogza

"Biology Education Research" or "Biology Didactics" is research that aims at highlighting and facilitating the process of teaching and learning about the biological world. Since the biological world is part of the natural world and thus the biological sciences are part of the natural sciences, one might consider "Biology Didactics" as *just* a part of "Science Didactics", the research field better known as "Science Education". In fact, a number of research questions addressed by "Biology Didactics" can be approached through theoretical constructs that have emerged within "Science Didactics" (Lewis, 2008). Nevertheless, the epistemological and psychological strands of thought that need to be taken into account when conducting research on the process of teaching and learning *biological* sciences in particular, seem to differ from those that need to be taken into account when conducting research on the process of teaching and learning other naturalsciences. I will consider in short, some epistemological and psychological issues that in my opinion seem to influence the teaching and learning of biological concepts and give rise to research questions that are to be asked in the context of "Biology Didactics" as a distinct domain of educational research.

Some epistemological issues

Understanding living organisms in the way we do today has been a difficult task for many centuries. Difficulties in understanding living things might be attributed to many factors, with the so-called "duality" of organisms being the dominant: it is what we "see" - phenotype - and it is what we "do not see" - genotype - that actually defines a living entity. This duality is traditionally troubling both students and those concerned with designing syllabuses or writing textbooks. What kind of explanation is more appropriate for understanding biological phenomena: molecular, organismic, evolutionary, ecological or all these probably together? Another source of difficulties has been the complex organization and function of living things (Mayr, 1988, 2004). The latter consist of chemical substances but cannot actually be thought as just chemical structures. They are self-organized in different levels, each of which shows different functions that contribute to the survival of the organism as a whole. The above may pinpoint to very interesting research questions

concerning the development of systems thinking in the context of biology education (Verhoeff et al, 2008).

Biological knowledge includes a long series of concepts with different degrees of complexity, abstraction and importance. Our effort when teaching biology should aim at providing students with the means to grasp concrete and descriptive concepts before they go on with the theoretical ones. Can we do this? The concept of gene for instance, has been altered many times since it was first introduced as a theoretical construct and it is still under modification (Gericke & Hagberg, 2007). How are we going to teach about genes then? Is it good to start with the Mendelian view of the gene first and move on to its molecular conceptualization, as a way to show the progress of scientific thought? Would it be better if we just focused on the molecular conceptualization of the gene as a piece of a DNA molecule - a chemical structure with a specific base sequence - and just forget about the Mendelian view? And which way can we help the younger students to start building a solid understanding about it? Can our research produce pedagogical theories that concern teaching and learning of key biological concepts? The Dutch school has actually shown the way (Knippels, M.-C., Waarlo, A.-J. & Boesma 2001; Boersma, K. Th.& Waarlo, A.-J. 2008).

In addition, biology is a very complex science in terms of research methodology, too. Its diversity is reflected in its many different scientific fields which have actually developed into separate biological sciences. Characteristics of their research methods are reflected in the way we teach some topics, especially when we try to adopt the inquiry-based teaching and learning model. To name just a few of them, it is the reductionist approach and its consequences in teaching and learning that should be addressed, as well as the difficulty to generalize and the different-level explanations that can be given to account for a certain phenomenon (see "functional" and "historical/evolutionary" explanations). The so-called "scientific method" has some common characteristics, but we have to consider those that are applied to biology and ask relevant research questions (Ganser & Hammann, 2008).

The psychology of learning biological concepts

Is there an autonomous intuitive biology?

Although there is no agreement among cognitive psychologists about when intuitive biology is emerged (age 4-5 or age 7-8) (Carey 1985, 1988; Keil et al., 1999; Inagaki & Hatano, 2002, 2006), all suggest that intuitive biology is a separate domain, distinct from those of intuitive psychology and intuitive physics. This practically means that we have different ways to think about living things in particular. It has been suggested that the emergence of a distinct domain of biology cognition could be evolutionary favored, since knowledge of animals and plants (potential food sources) (Wellman & Gelman, 1992), as well as knowledge of bodily functions (Hatano & Inagaki, 1994) might be crucial to the survival of human beings.

Intuitive biology is characterized by the developing ability to make some key ontological distinctions like for instance the "mind-body" one, as well as by the activation of special reasoning devices with regard to the biological world. According to Inagaki and Hatano (2002), these are (a) the "personified" predictive device which gives young children the

opportunity to make rational predictions about attributes of living entities according to how much they look like humans, (b) the "teleological-vitalistic" explanatory device, that leads to intention-free explanations about why several bodily functions are performed, and (c) the "essentialist" reasoning device that leads children to categorize living entities on the basis of their unique, internal "essence" which remains intact throughout life. Intuitive biology switches to more advanced, school-biology when "mechanistic" or even "evolutionary" reasoning can be performed. However, elements of intuitive biology can be traced even in lay adults, especially when it comes to demanding, theoretically-laden phenomena like inheritance or evolution.

What this means for Biology Didactics & Biology Education?

Biology Didactics can be thought of as a separate domain of research not only on epistemological grounds, but also by appealing to the psychology of acquisition of biological knowledge. The latter may guide the formulation of research questions concerning the development of age-bound learning environments about the biological world. In particular, it seems that we can start education in special topics of biology from the early years (age 4-5) and ask questions about children's shift from one way of thinking to another (e.g. from intentional to vitalistic and mechanistic or from analogical human-based to category-based). The development of more advanced conceptual structures may be pursued more effectively later on, if work on children's intuitive ways of thinking about biological phenomena has been preceded.

Coda

Biology Didactics seems to be a distinct domain of educational research that can be enriched by taking into account the special aspects of Biology:

- Its epistemological basis that gives biology education a privilege to introduce important concepts (e.g. teleology or randomness) as well as different levels of explanation for biological phenomena.
- Its special background in terms of naïve biology that intermingles with conceptual understanding (essentialist thought and inheritance, teleology and evolutionary thought, etc.)

Finally, although not discussed here, I think that the following are quite interesting as well:

- Biology and culture: research about the relevance of biology in everyday life taking into account cultural influences in biology understanding that have been reported.
- Biology, technology and society: education for scientific literacy and the socio-scientific issues has been a great area for research and we should seek to find unexplored issues so far.

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