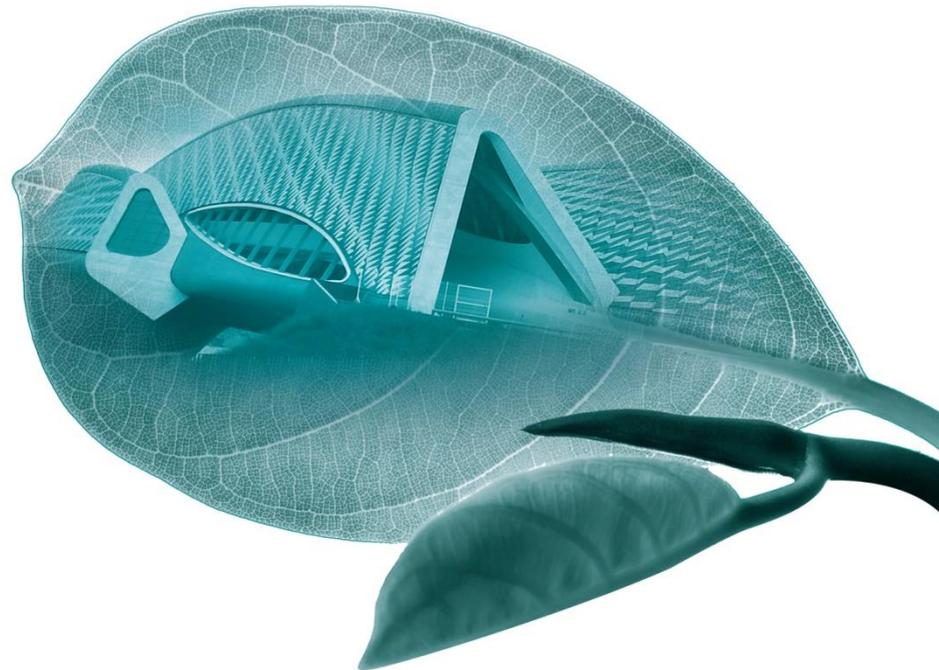


2nd - 6th July

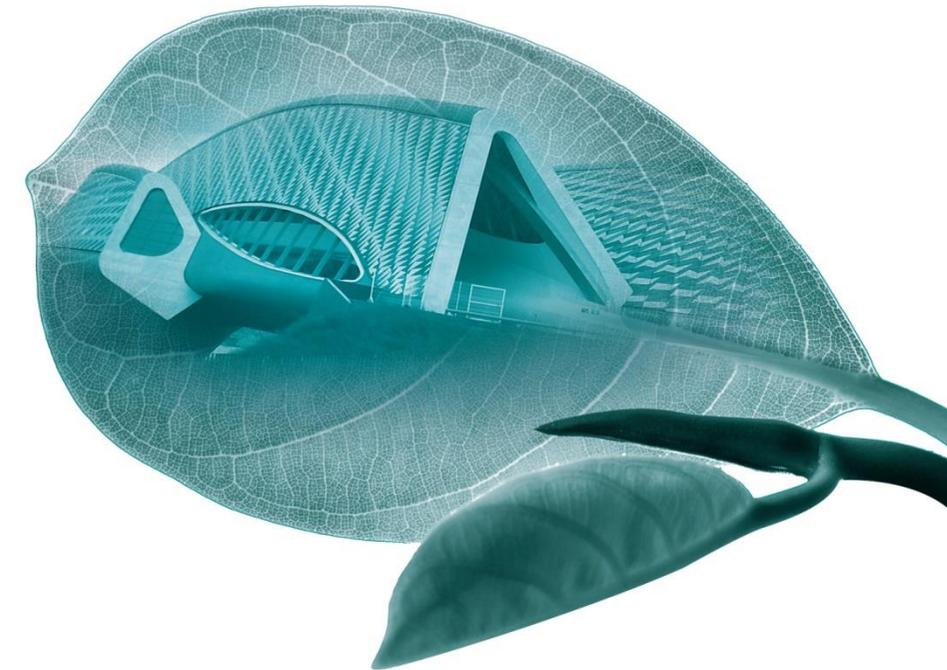
# XII CONFERENCE OF EUROPEAN RESEARCHERS IN DIDACTICS OF BIOLOGY

## ERIDOB 2018

July from 2nd to 6th 2018  
Faculty of Education / Zaragoza / Spain



ERIDOB 2018 Zaragoza



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## ACADEMIC COMMITTEE

Dr Orit Ben Zvi Assaraf, Ben-Gurion University of the Negev, Israel  
Dr Marida Ergazaki, University of Patras, Greece  
Dr Niklas Gericke, Karlstad University, Sweden  
Dr Marcus Grace, Southampton University, UK (Chair)  
Dr Marie-Christine Knippels, University of Utrecht, Netherlands  
Dr Konstantinos Korfiatis, University of Cyprus, Cyprus  
Dr Blanca Puig, University of Santiago de Compostela, Spain  
Dr Jörg Zabel, Leipzig University, Germany

## LOCAL ORGANIZING COMMITTEE

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## **FOREWORD**

The ERIDOB Academic Committee invites researchers in Didactics of Biology/Biology Education to take part in the Twelfth Conference of European Researchers in Didactics of Biology (ERIDOB). The Conference will be held at the Zaragoza University, Spain, from July 2<sup>nd</sup> – July 6<sup>th</sup> 2018.

The aim of the conference is to give researchers the opportunity to present and discuss their research work and results. Contributions should fit into one of the following strands within Biology Education:

- Students' conceptions and conceptual change
- Students' interest and motivation
- Students' values, attitudes and decision-making
- Scientific thinking, nature of science and argumentation
- Teaching strategies and teaching environments;
- Teaching and learning with educational technology
- Environmental education
- Health education
- Social, cultural, and gender issues
- Practical work and field work
- Research methods and theoretical issues

## **PREVIOUS ERIDOB CONFERENCES**

Karlstad, Sweden 2016

Haifa, Israel, 2014

Berlin, Germany 2012

Braga, Portugal 2010

Utrecht, Netherlands 2008

London, United Kingdom 2006

Patras, Greece 2004

Toulouse, France 2002

Santiago de Compostela, Spain 2000

Göteborg, Sweden 1998

Kiel, Germany 1996

## **FUNDING AND SPONSORS**

The XII<sup>th</sup> Eridob Conference at Zaragoza has been funded and sponsored by:

**University of Zaragoza**

<http://www.unizar.es/>

**Faculty of Education**

<http://educacion.unizar.es/>

**Environmental Sciences Institute (IUCA)**

<http://iuca.unizar.es/>

**Zaragoza Municipality**

[www.zaragoza.es](http://www.zaragoza.es)

**Taylor & Francis through the Journal of Biological Education**

<https://www.tandfonline.com/loi/rjbe20>

**Universidad de Santiago de Compostela**

[www.usc.es](http://www.usc.es)

## WELCOME TO ERIDOB 2018 IN ZARAGOZA!

Dear colleagues

It gives us a great pleasure to welcome you to the University of Zaragoza and the XII<sup>th</sup> European Researchers in Didactics of Biology (ERIDOB) conference. It has been jointly organized by the University of Zaragoza and the University of Santiago de Compostela.

18 years ago, the third ERIDOB Conference took place in Santiago de Compostela and it is a pleasure for us to receive all of you again in Spain. We are confident that the ERIDOB conference will be an excellent opportunity to present your work, but also to undertake in depth discussions with other scholars in the field. The number of participants (187); will lead us to fruitful exchanges among researchers in a pleasant atmosphere. We are happy to announce that our community has expanded and this year we also have participants from as far as New Zealand.

The wide range of research topics addressed during the conference will lead us through an intellectually stimulating week. There are many interesting oral and poster presentations to look forward to. We also have present two widely respected keynote presenters, María Pilar Jiménez Aleixandre from the University of Santiago de Compostela and Jesús Martínez de la Fuente from the University of Zaragoza. The conference also includes three symposia: *Genetic determinism and students' understanding of gene-trait relationships*; *Understanding and Acceptance of Evolution in the Light of Threshold Concepts* and *Thoughtfulness in Biology Education*. In addition, we have arranged a Round Table discussion about "Publishing in Biology Education Research"

The XII<sup>th</sup> ERIDOB conference also incorporates two innovations: An Early Career Researchers' meeting, which is an informal meeting for PhD students, postdoctoral colleagues or anyone who feels that they are an early career researcher, to exchange opinions and experiences about researching in Biology Education, and a Researchers' Café, which is an open session where an individual or a group of researchers can present projects or relevant information to the ERIDOB community. Furthermore, different social activities are planned including different visits to natural and cultural areas of Zaragoza and the rest of the province, the reception at the Paraninfo and the conference dinner. All these activities will provide additional occasions for informal meetings and discussions.

We hope that the conference will be an enjoyable experience for all participants. Zaragoza, the host city, deserves your time for its mediaeval castle, its basilica and its narrow streets, where you can find taverns with delicious Spanish food and wine. We also encourage you to take time and visit the rest of the Aragon.

Many people have contributed to the organization. We would like to acknowledge the steady support of The Academic Committee reviewing and planning the conference, as well as the substantial contributions of the members of both Local Organizing Committees. We are deeply indebted to the reviewers; without their contributions it would have been impossible to put together the scientific programme. Finally, we would also like to thank the funders and sponsors (see separate list).

We would also like to thank all of you, the participants of the conference, for submitting your quality proposals of and for bringing your ideas and experiences to bear on making the XII<sup>th</sup> ERIDOB a memorable event. The conference is hosted by the Faculty of Education and the Department of Didactic of Experimental Sciences at University of Zaragoza, Spain.

We wish you a fruitful and happy week.

## REVIEWERS

All the submitted proposals for the conference have been anonymously reviewed by at least two senior researches. Here follow the list of the reviewers of the conference

Ana María	Abril Gallego	Universidad de Jaén	Spain
Arnau	Amat	Universitat de Vic	Spain
Orit	Ben Zvi Assaraf	Ben-Gurion University Of The Negev	Israel
Paloma	Blanco Anaya	Universidade De Santiago De Compostela	Spain
Franz X.	Bogner	University Of Bayreuth	Germany
Ánxela	Bugallo	Universidade De Coruña	Spain
Jenny	Byrne	University Of Southampton	England
Nina	Christenson	Karlstad University	Sweden
Laura	Colucci-Gray	University Of Aberdeen	Scotland
Michiel	Dam	Leiden University, Iclon	Netherlands
Justin	Dillon	University Of Bristol	England
Arne	Dittmer	University Of Regensburg	Germany
Marida	Ergazaki	University Of Patras	Greece
Magali	Fuchs-Gallezot	Université Paris-Sud	France
Isabel	García-Rodeja	Universidade De Santiago De Compostela	Spain
Niklas	Gericke	Karlstad University	Sweden
María J.	Gil-Quílez	University Of Zaragoza	Spain
Melissa	Glackin	King's College London	England
Marcus	Grace	University Of Southampton	England
Helge	Gresch	University Of Münster	Germany
Marcus	Hammann	Westfälische Wilhelms Universität Münster	Germany
Pam	Hanley	University Of York	England
Ute	Harms	Ipn	Germany
Mª Pilar	Jiménez-Tejada	University Of Granada	Spain
Marie-Christine	Knippels	Utrecht University	Netherlands

Konstantinos	Korfiatis	University Of Cyprus	Cyprus
Moritz	Krell	Freie Universität Berlin	Germany
Anna	Marba Tallada	Universidad Autónoma De Barcelona	Spain
Beatriz	Mazas	Universidad De Zaragoza	Spain
Birgitta	McEwen	Karlstad University	Sweden
Marcelo Tadeu	Motokane	University Of São Paulo	Brazil
Denise	Orange	Université Lille 3 - France	France
Christina	Ottander	Umea University	Sweden
Penelope	Papadopoulou	University Of Western Macedonia	Greece
Miia	Rannikmae	University Of Tartu	Estonia
Michael	Reiss	Ucl Institute Of Education	England
Ros	Roberts	Durham University	England
Eliza	Rybska	Adam Mickiewicz University	Poland
David	Slingsby	Royal Society Of Biology	England
Andrej	Šorgo	University Of Maribor	Slovenia
Ulrike	Spörhase	University Of Education Freiburg - Pädagogische Hochschule Freiburg	Germany
Laura	Valdes	Autonomous University Of Barcelona	Spain
James	Williams	University Of Sussex	England
Mark	Winterbottom	University Of Cambridge	England
Anat	Yarden	Weizmann Institute Of Science	Israel
Βασιλική	Ζόγκζα	University Of Patras	Greece
Jörg	Zabel	Universität Leipzig	Germany

## INSTRUCTIONS FOR PRESENTATIONS

### Posters and poster presentations

The conference poster boards accept up to 120 (high) and 90 (wide) sizes, so a portrait layout would be preferable. A1 and A0 posters are acceptable. They are pin boards (pins will be provided).

The audience presentation will first take place in the classroom as shown in the program, while the posters will be put up on the boards at the central corridor outside the lecture room.

### Oral presentations (paper presentations)

The oral presentations should be maximum **15 minutes** long. In addition there will be time for **5 minutes** of questions and/or discussions after each presentation. Computers and projectors are available in all rooms. The easiest way is to bring your presentation on a memory stick and upload your presentation before the session starts.

### Symposia

Symposia follow the same procedure as the oral presentations. Note that the number of participants might differ between symposia and there might be more time available for discussions at some symposia. The chair of the symposia is responsible for the timing of the symposia, and if there should be a longer summarizing discussion after all presentations are completed or short discussions after each paper.

### Chair

The chair is responsible for that the session starts in time and that all presentations are given equal time frames. A few sessions include fewer or more contributions and in that case the time for discussion is extended or shortened accordingly, not the presentations. The chair takes responsibility for these possible accommodations.

## INFORMATION ABOUT SUBMISSION OF PAPERS FOR THE ERIDOB 2018 PROCEEDINGS

All papers that were accepted for the ERIDOB 2018 conference, for a symposium, an oral or for a poster presentation, are welcomed to be considered for publication in the Eridob2018 Book.

**Submissions:** Please submit your paper as a Microsoft WORD for Windows file to the [EasyChair](#) system. You will find the link at the conference website: <https://eventos.unizar.es/8746/section/11073/twelfth-conference-of-european-researchers-in-didactics-of-biology-eridob-2018.html>

**The deadline:** The final deadline for submission of papers is October 30th, 23:00 (CET).

**Note** that high quality papers will be selected for a special issue of the *Journal of Biological Education*.

**The format:** for instructions see the conference website Participation/Proceedings

# **PROGRAMME**

## PROGRAMME AT A GLANCE

<b>Monday July 2nd</b>			
<b>Time</b>	Location: <i>Paraninfo Universidad de Zaragoza</i> ( <a href="https://www.unizar.es/information-institution/name-and-address">https://www.unizar.es/information-institution/name-and-address</a> )		
09:00-15:00	Arriving at Zaragoza		
17:00-20:00	Registration		
18:30-19:30	Opening ceremony		
19:30-21:00	Welcome Reception		
<b>Tuesday July 3rd</b>			
<b>Time</b>	Location: Facultad de Educación ( <a href="https://educacion.unizar.es/en">https://educacion.unizar.es/en</a> )		
09:00-10:30	Key Note 1: <i>María Pilar Jiménez Aleixandre</i> <b>How to gather and analyse quality evidence about successful biology classrooms</b>		
10:30-11:00	Coffee Break		
11:00-12:15	Paper Session 1a Symposium 1	Paper Session 1b	Paper Session 1c
12:15-13:30	Paper Session 2a Symposium 2	Paper Session 2b	Paper Session 2c

13:30- 15:00	Lunch		
15:00- 16:30	Poster Session 1a	Poster Session 1b	Poster Session 1c
16:30- 17:00	Coffee Break		
17:00- 18:30	Paper Session 3a	Paper Session 3b	Paper Session 3c
18:40- 19:40	Early Career Researchers' meeting point *		

\* An informal meeting for PhD students, postdoctoral or anyone who feels that they are an early career researcher, to exchange opinions and experiences about researching in Biology Education.

<b>Wednesday July 4th</b>			
<b>Time</b>	Location: Facultad de Educación ( <a href="https://educacion.unizar.es/en">https://educacion.unizar.es/en</a> )		
9:00-10:30	Paper Session 4a	Paper Session 4b	Paper Session 4c
10:30- 11:00	Coffee Break		
11:00- 12:15	Paper Session 5a  Symposium	Paper Session 5b	
12:15- 13:30	Paper Session 6a	Paper Session 6b	Paper Session 6c
13.30:15:00	Lunch		
16:00- 20:00	Tours - social event		

## Thursday July 5th

### Time

Location: Facultad de Educación  
(<https://educacion.unizar.es/en>)

9:00-10:00	Paper Session 7a	Paper Session 7b	Paper Session 7c	
10:00-11:30	Paper Session 8a	Paper Session 8b	Paper Session 8 c	
11:30-12:00	Coffee Break			
12:00-13:30	Poster Session 2a	Poster Session 2b	Poster Session 2c	
13:30-15:00	Lunch			
15:00-16:00	Business meeting			
16:00-16:30	Coffee Break			
16:30-17:30	Poster Session 3a	Poster Session 3b	Poster Session 3c	Poster Session 3d
17:30-18:30	Researchers' café *			
20:00-23:30	Conference Dinner			

\* An open space where an individual or group of researchers can present projects or relevant information for the ERIBOD community. Please let the Academic Committee know in advance if you wish to present something.

## Friday July 6th

**Time**

Location: Facultad de Educación

(<https://educacion.unizar.es/en>)

### **Round table about “Publishing in Biology Education Research”**

9:00-9:45

Tom Ireland, Editor of *The Biologist* and Managing Editor of the *Journal of Biological Education* (Royal Society of Biology, UK), Kostas Kampourakis (University of Geneva, Switzerland) and Michael Reiss (University College London, UK) .

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Key note 2: *Jesús Martínez de la Fuente*

9:45-10:45

**Nanomedicine: New Challenges for Biotechnology**

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10:45-11:15

Coffee Break

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11:15-12:15

Paper Session 9a

Paper Session 9b

Paper Session 9c

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12:15-13:00

Closing ceremony

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13:30-15:00

Lunch

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## DETAILED PROGRAMME

### Monday July 2nd

Location: *Paraninfo Universidad de Zaragoza*

(<https://www.unizar.es/information-institution/name-and-address>)

- 17:00-20:00 Registration
- 18:30-19:30 Opening ceremony
- 19:30-21:00 Welcome Reception

### Tuesday July 3rd

Location: Facultad de Educación . (<https://educacion.unizar.es/en>)

Key Note 1: *María Pilar Jiménez Aleixandre*

- 09:00-10:30 **How to gather and analyse quality evidence about successful biology classrooms**

*Chair: Marcus Grace*

*Location: Conference hall (basement)*

- 10:30-11:00 Coffee Break

Paper Session 1a - Symposium 1 (Strand: 1. Students' conceptions and conceptual change)

- 11:00-12:15 **Title: Genetic determinism and students' understanding of gene-trait relationships**

*Chair: Michael Reiss*

*Location: 0.5( ground floor)*

**Title** **Students' Conception of the Relationship between Genes and Traits Affects their Understanding of Genetic Mechanisms**

**Authors** *Michal Haskel-Ittah and Anat Yarden*

**Title** **The Formation of Traits: A Framework for Systematizing Students' Problems of Explanatory Coherence and for Analyzing Teaching Materials in Genetics Education**

**Authors** *Marcus Hammann and Tim Heemann*

**Title** **Investigating the Relationship Between Beliefs in Genetic Determinism as Related to Knowledge in Genetics and Genomics**

**Authors** *Niklas Gericke, Rebecca Carver, Jérémy Castéra, Neima Alice Menezes*

*Evangelista, Claire Coiffard Marre and Charbel N. El-Hani*

**Title** **Students' implicit associations between genetics concepts and essentialist/teleological intuitions**

*Authors* *Kostas Kampourakis, Florian Stern and Andreas Müller*

Paper Session 1b (Strand: 2. Students' interest and motivation)

11:00-12:15 *Chair: Alexander Eckes*

*Location:0.6 (ground floor)*

**Title** **Bringing together what belongs together: theory & practice and children & nature**

*Authors* *Lara Weiser and Annette Scheersoi*

**Title** **Collaborative care for animals in class – Effects on the students' relatedness and their flow experience in biology lessons**

*Authors* *Alexander Eckes, Nadine Großmann, Annette Textor and Matthias Wilde*

**Title** **Motivation of Newly Arrived Students in the Science Classroom – "If one wants to become a doctor he has to study Biology."**

*Authors* *Mario Schmiedebach and Claas Wegner*

**Title** **The motivation level of Soweto students towards learning biology**

*Authors* *Dudrah Moyo and Lindelani Mnguni*

Paper Session 1c (Strand: 5. Teaching strategies and teaching environments)

11:00-12:15 *Chair: Andri Christodoulou*

*Location:0.7 (ground floor)*

**Title** **Teaching & learning laboratories in biology teacher education: Analysis of students' reflections on teaching experiences**

*Authors* *Antje Saathoff and Corinna Hößle*

**Title** **Understanding immunobiological processes – Using everyday conceptions in group discussions**

*Authors* *Sonja Tinapp and Jörg Zabel*

**Title** **Learning to design biology lessons based on socio-scientific inquiry based learning (SSIBL)**

*Authors* *Andri Christodoulou, Ruth Amos, Christina Ottander and Katarina Ottander*

**Title** **Learning the Control-of-Variables Strategy: What works best?**

*Authors* Johanna Kranz, Tobias Tempel, Katrin Kaufmann and Andrea Möller

Paper Session 2a-Symposium 2 (Strand: 1. Students' conceptions and conceptual change)

12:15-13:30

**Title: Understanding and Acceptance of Evolution in the Light of Threshold Concepts**

*Chair: Ute Harms*

*Location: 0.5( ground floor)*

**Title**

**Using cluster analysis for categorization of student explanations of natural selection**

*Authors* Andreas Göransson , Daniela Fiedler , & Lena Tibell

**Title**

**Knowledge of Randomness and Probability as Predictor for Understanding and Acceptance of Evolution**

*Authors* Ross Nehm, Daniela Fiedler, Gena Sbeglia, & Ute Harms

**Title**

**Simulation EvoSketch: Learning Randomness and Probability in Evolution**

*Authors* Daniela Fiedler & Ute Harms

**Title**

**Visualizing time in evolution**

*Authors* Jörgen Stenlund & Lena A. E. Tibell

Paper Session 2b (Strand: 4. Scientific thinking, nature of science and argumentation)

12:15-13:30

*Chair: Melanie Peffer*

*Location:0.6 (ground floor)*

**Title**

**Dialogue and Linguistic scaffolds as tools to help students making investigable questions**

*Authors* Concepció Ferrés Gurt and Jordi Domènech Casal

**Title**

**The history of biology and the promotion of good questions in the learning of the plasma membrane**

*Authors* Carol Joglar, Sandra Patricia Rojas R. Rojas, Ricardo De La Fuente and Veronica Astroza

**Title**

**Influence of Self-Efficacy and Motivation on Undergraduate Science Inquiry Practices**

*Authors* Melanie Peffer and Emily Royse

12:15-13:30 Paper Session 2c (Strand: 8. Health education)  
*Chair: Claes Malmberg*  
*Location: 0.7 (ground floor)*

**Title** **Promotion of emotional competence in inclusive human biology lessons in class 5/6**

*Authors* *Laura Ferreira Gonzalez, Igor Osipov, Dennis Hövel, Thomas Hennemann and Kirsten Schlüter*

**Title** **Health and wellbeing – the school garden, a place to feel good**

*Authors* *Susan Pollin and Carolin Retzlaff-Fürst*

**Title** **Nutrition education and citizenship - Individual responsibility and democratic politics**

*Authors* *Claes Malmberg and Anders Urbas*

**Title** **The significance of school biology in everyday life: a case of HIV/AIDS knowledge among South African schoolgirls**

*Authors* *Lindelani Mnguni*

13:30-15:00 Lunch

15:00-16:30 Poster Session 1a (Strand: 1. Students' conceptions and conceptual change)  
*Chair: Aritz Uskola*  
*Location: 0.5( ground floor)*

<b>Authors</b>	<b>Title</b>
Aritz Uskola, Begoña Burgoa, Teresa Zamalloa and Gurutze Maguregi	Immune system model constructed by elementary pre-service teachers in a context about allergies and intolerances
Noureddine Zghida and Zouhaire Lamrani	Nutrition and reproduction students' conceptions regarding to animal classification
Sarah Schmid and Franz X. Bogner	Students' conceptions about the urban water-cycle
Theresa Heidenreich and Harald Gropengießer	The scientific clarification as the central task of lesson content design
Zofia Chyleńska and Eliza Rybska	A frog in a school throat – obstacles in sources of the students scientific knowledge about herpetology.

Bernat Esquiús Monrós and Arnau Amat Vinyoles	'How are plants dispersed?'. Children's Intuitive ideas in 6th grade
Jordi Domènech	Using problematized contexts to introduce the idea of classification criteria in taxonomy. Context-transference and resistant ideas.
María Martínez-Chico, Farida Abou Akl Sánchez and M.Rut Jiménez Liso	I won't believe it until I see it? An inquiry-based sequence on "Microorganisms" for secondary school

15:00-16:30

Poster Session 1b (Strand: 1. Students' conceptions and conceptual change)

*Chair: Eliza Rybska*

*Location: 0.6( ground floor)*

<b>Authors</b>	<b>Title</b>
Rita Gazdag, Martin Willmann, Jörg Großschedl and Marcel Bucher	Learning in a science outreach laboratory: Development of a learning material on the ecology of the rhizosphere
Arnau Amat, Laura Martín and Isabel Jiménez	How the nutrition function of the human body is explained by elementary pre-service teachers
Katharina Düsing, Roman Asshoff and Marcus Hammann	The Levels of Biological Organisation – Engaging with Students' Conceptions and Promoting a Coherent Understanding Using the Example of the Carbon Cycle
Peter Lampert, Suzanne Kapelari, Michael Kiehn and Martin Scheuch	Understanding Reproduction in Plants
Eliza Rybska and Jelle Boeve-De Pauw	Drawings on biology. How can drawings help to conceptualize flowers?
Helin Semilariski, Anne Laius and Uko Viisut	Analysis of the results of the university entrants' tests in biology

15:00-16:30

Poster Session 1c (Strand: 5. Teaching strategies and teaching environments)

*Chair: Tali Tal*

*Location: 0.7( ground floor)*

<b>Authors</b>	<b>Title</b>
Isabel Jiménez Bargalló, Arnau Amat Vinyoles and Jordi Martí Freixas	Scientific posters within biodiver project: formative assessment in undergraduate primary teachers' courses

	Tali Tal, Irene Bayer and Kara Haas	Elementary School Teachers Learning Life-Sciences Outdoors
	José María Marcos-Merino, Rocío Esteban Gallego and Jesús Gómez Ochoa de Alda	Training pre-service teachers to approach interdisciplinary: learning Physics and Chemistry at Biology lessons
	Katrin Kaufmann and Andrea Moeller	Influence of Role Assignment on Student Activity during Cooperative Inquiry Learning in Science Class
	Helge Gresch	Dealing with Teleological Explanations – A Language Issue in Evolution Classes?
	Idit Adler, Tali Tal, Irene Bayer, Jane Lee, Stephen Modell, Ella Greene-Moton, Toby Citrin and Joseph Krajcik	“Models in action”: Using scientific knowledge for social action to support science learning
	Beatriz Carrasquer Álvarez, Adrián Ponz Miranda and M <sup>a</sup> Victoria Álvarez Sevilla	The floral diagram as a didactic resource
	Irma Mavrič Gavez and Gregor Torkar	Herbarium in primary teacher education
	Emilio Costillo, Isaac Corbacho, Ana Belén Borrachero, María Carmen Conde, José Samuel Sánchez and Vicente Mellado	Cognitive and affective domains in nature field trips designed by prospective teachers
	Bianca Kuhlemann and Corinna Hößle	Students of Biology Teacher Education develop diagnostic tasks and assess their potential
16:30-17:00	Coffee Break	
	Paper Session 3a (Strand: 2. Students’ interest and motivation)	
17:00-18:30	<i>Chair: Ute Harms</i>	
	<i>Location: 0.5( ground floor)</i>	
<b>Title</b>	<b>Academic Self-Concept and its Relation to Achievement – Biology-Specific or Science bound?</b>	
<b>Authors</b>	<i>Jörg Großschedl, Virginia Welter and Ute Harms</i>	
<b>Title</b>	<b>Microbiology learning through homemade microorganisms’ culture: role of students’ emotions and values</b>	

*Authors* José María Marcos-Merino, Rocío Esteban Gallego and Jesús Gómez Ochoa de Alda

***Title*** Long-term knowledge over one year with a student-centered inquiry-based learning module about bionics.

*Authors* Michaela Marth and Franz X Bogner

***Title*** Engaging students in studying Human biology through Digital Storytelling

*Authors* Maria Dokopoulou and Evangelia Pavlatou

17:00-18:30 Paper Session 3b (Strand: 3 Students' values, attitudes and decision-making)

*Chair: Janice Griffiths*

*Location: 0.6( ground floor)*

***Title*** Decision Making Considerations of Israeli Religious Undergraduate Students in the Field of Genetic Testing and Genetic Counseling.

*Authors* Merav Siani and Orit Ben-Zvi Assaraf

***Title*** Decision-making competence regarding the possibilities of genome editing

*Authors* Laura Maria Heinisch, Corinna Hößle, Ulrike-Marie Krause and Wiebke Rathje

***Title*** Evolution, affect and acceptance: A psychoanalytical examination of the controversy

*Authors* Emma Newall

***Title*** Persuasive effects of role-play about a socio-scientific issue

*Authors* Melanie Basten and Matthias Wilde

***Title*** Students' views on the value of protecting biodiversity

*Authors* Marcus Grace, Carys Hughes and Janice Griffiths

17:00-18:30 Paper Session 3c (Strand: 7. Environmental education)

*Chair: Michael Reiss*

*Location: 0.7( ground floor)*

***Title*** Ecosystems in science education research in the last 20 years

*Authors* Pedro Lucha and María José Sáez Bondía

***Title*** An analysis of seventh grade students' mental models concerning climate change

*Authors* Vanessa Sesto and Isabel García-Rodeja

**Title** **Regenerating our place: Fostering a sense of place through rehabilitation and place-based education**

*Authors* *Wisam Sedawi, Orit Ben Zvi- Assraf and Michael Reiss*

**Title** **“This curse of knowledge...” How do biodiversity scientists connect their expertise to their understanding of nature?**

*Authors* *Judith Wiegelmann and Jörg Zabel*

**Title** **Measurement Tools for the Competence Model for Environmental Education**

*Authors* *Lisa Felix-Strishock, Bruce Johnson and Sanlyn Buxer*

18:40-19:40 Early Career Researchers’ meeting point

Location: 0.5 (ground floor)

### Wednesday July 4th

Location: Facultad de Educación (<https://educacion.unizar.es/en>)

9:00-10:30 Paper Session 4a (Strand: 4. Scientific thinking, nature of science and argumentation)

*Chair: Birgitta Berne*

*Location: 0.5( ground floor)*

**Title** **Learning using contradictory texts promotes students' critical thinking**

*Authors* *Moriah Ariely and Anat Yarden*

**Title** **Assessing professional vision of biology teacher students**

*Authors* *Friederike Kaiser and Philipp Schmiemann*

**Title** **Contingency in Peer Scaffolding when Addressing Socio-scientific Issues in Biotechnology**

*Authors* *Birgitta Berne*

9:00-10:30 Paper Session 4b (Strand: 5. Teaching strategies and teaching environments)

*Chair: Sue Dale-Tunnickliffe*

*Location: 0.6( ground floor)*

**Title** **Teaching to teach the model of evolution in Primary Education: an experience with pre-service teachers at a Spanish university**

<i>Authors</i>	<i>Lucía Vázquez-Ben and Ánxela Bugallo-Rodríguez</i>
<b><i>Title</i></b>	<b>A role-change approach in biology pre-service-teacher education at an outreach lab: a direct replication study adding a new focus on module-phase-dependent development of pedagogical content knowledge</b>
<i>Authors</i>	<i>Franz-Josef Scharfenberg and Franz X. Bogner</i>
<b><i>Title</i></b>	<b>Natural history dioramas for teaching biodiversity on an ecosystem level: Programme for pre-service biology teacher education</b>
<i>Authors</i>	<i>Špela Hrast, Ljerka Trampuž, Staša Tome, Sue Dale Tunnicliffe and Gregor Torkar</i>
<b><i>Title</i></b>	<b>Pre-service teachers' use of research: from pedagogic soup to reflective practitioners through conjecture maps?</b>
<i>Authors</i>	<i>Francois Lombard, Laura Weiss and Marie Merminod</i>
<b><i>Title</i></b>	<b>Discipline-based or context-based? A comparison of Biology curriculum in four countries.</b>
<i>Authors</i>	<i>Edith Dempster</i>
9:00-10:30	<p>Paper Session 4c (Strand: 5. Teaching strategies and teaching environments)</p> <p><i>Chair: Roald Verhoeff</i></p> <p><i>Location: 0.7( ground floor)</i></p>
<b><i>Title</i></b>	<b>Topic-specific didactics in biology in higher education – easily achieved but absent in biology faculty teaching</b>
<i>Authors</i>	<i>Kristina Andersson and Annica Gullberg</i>
<b><i>Title</i></b>	<b>Make biology relevant again! Student teachers' views on the relevance of biology education</b>
<i>Authors</i>	<i>Justus Mutanen and Anna Uitto</i>
<b><i>Title</i></b>	<b>Can prompt-cards support students' self-efficacy regarding experimentation and their quality of motivation during experimentation in biology lessons?</b>
<i>Authors</i>	<i>Cornelia Stiller, Alexandra Stümmeler and Matthias Wilde</i>
<b><i>Title</i></b>	<b>Systems thinking and the theoretical nature of seeing coherence</b>
<i>Authors</i>	<i>Roald Verhoeff, Melde Gemma Regina Gilissen and Marie-Christine Knippels</i>
<b><i>Title</i></b>	<b>Storytelling as an educational tool in biology teaching: a pilot study</b>
<i>Authors</i>	<i>Nausica Kapsala and Evangelia Mavrikaki</i>

10:30-11:00 Coffee Break

Paper Session 5a Symposium (Strand: 5. Teaching strategies and teaching environments)

11:00-12:15 **Title: Thoughtfulness in Biology Education**

*Chair: Marie-Christine Knippels*

*Location: 0.5( ground floor)*

**Title Multi-disciplinary reflections on Thoughtfulness in Biology Education**

*Authors Paul Davies, Haira Emanuela Gandolfi, Ralph Levinson & Stephen Price*

**Title Narratives as a way to foster thoughtfulness in biology education**

*Authors Marie-Christine Knippels, Jörg Zabel, Julia Zdunek & Alexandra Slegers*

**Title The Role of Students' Beliefs about Neuroscientific Research in Moral and Philosophical Reasoning**

*Authors Alexander Bergmann & Jörg Zabel*

**Title Thoughtful Teachers, Thoughtful Moments, Thoughtful Students? – A Critical Reflection on the Culture of Learning in Biology Classes and Biology Teacher Training**

*Authors Arne Dittmer & Britta Lübke*

Paper Session 5b (Strand: 4. Scientific thinking, nature of science and argumentation)

11:00-12:15

*Chair: Orit Ben-Zvi Assaraf*

*Location: 0.6( ground floor)*

**Title Use of Evidence by 3-4 and 5-6 year-olds: a Comparative Study**

*Authors Sabela F. Monteiro, María Pilar Jiménez-Aleixandre and Pablo Brocos*

**Title Effects of redundancy in multiple external representations on biology test performance**

*Authors Lara Magnus, Kerstin Schütte and Julia Schwanewedel*

**Title Comparison of Student Primary Literature Reading Approaches to a Deep and Surface Learning Model**

*Authors Kirk Hepburn, Emily Leaman, George Ogolo, Tamunoibim Sambo and Nienke van Houten*

**Title A short intervention that promotes the abstract reasoning scheme improves ninth graders' achievements in photosynthesis**

<i>Authors</i>	<i>Reuven Babai and Esty Fridman</i>
12:15–13:30	<p>Paper Session 6a (Strand: 4. Scientific thinking, nature of science and argumentation)</p> <p><i>Chair: Marcus Grace</i></p> <p><i>Location: 0.5( ground floor)</i></p>
<b>Title</b>	<b>Is teaching Biology through socioscientific issues enough for the development of argumentation skills?</b>
<i>Authors</i>	<i>Martha Georgiou, Evangelia Mavrikaki and Constantinos Constantinou</i>
<b>Title</b>	<b>Students' arguments and reasoning in genetics: dealing with the complex interactions between genotype and phenotype in the expression of animal diseases.</b>
<i>Authors</i>	<i>Noa Ageitos Prego, Laura Colucci-Gray and Blanca Puig</i>
<b>Title</b>	<b>Students' Reasoning About Teleological Agency</b>
<i>Authors</i>	<i>Friederike Trommler and Marcus Hammann</i>
12:15–13:30	<p>Paper Session 6b (Strand: 5. Teaching strategies and teaching environments)</p> <p><i>Chair: Jelle Boeve-de Pauw</i></p> <p><i>Location: 0.6( ground floor)</i></p>
<b>Title</b>	<b>Fostering prospective biology teachers' diagnostic competence – Effects of an intervention on basic diagnostic skills</b>
<i>Authors</i>	<i>Tobias Alexander Joos and Ulrike Spörhase</i>
<b>Title</b>	<b>Recording and Promotion of subject-specific Professional Knowledge and Beliefs of prospective Biology Teachers</b>
<i>Authors</i>	<i>Katharina Gimbel and Kathrin Ziepprecht</i>
<b>Title</b>	<b>What TIMSS tells us about education for sustainable development - a comparative study between biology and science teachers in Sweden</b>
<i>Authors</i>	<i>Jelle Boeve-De Pauw and Niklas Gericke</i>
<b>Title</b>	<b>The effects of teacher self-efficacy and experienced Biology lessons as a student at school on prospective teachers' beliefs about teaching and learning Biology</b>
<i>Authors</i>	<i>Fabian Schumacher, Melanie Basten and Matthias Wilde</i>
12:15–13:30	<p>Paper Session 6c (Strand: 9. Social, cultural, and gender issues)</p> <p><i>Chair: Bev France</i></p>

*Location: 0.7( ground floor)*

**Title** **Giving the silent a voice: How rangatahi used Actor-Network Theory to unravel the complexity of a New Zealand native forest ecosystem.**

*Authors* *Bev France and Sally Birdsall*

**Title** **Gender differences of estonian gymnasium students' biological cognitive skills within socio-scientific issue of lactose intolerance**

*Authors* *Anne Laius, Helin Semilarski and Uko Viisut*

**Title** **Differences in subject teachers' perceptions of their role in promoting sustainability school culture**

*Authors* *Anna Uitto and Seppo Saloranta*

**Title** **Teaching for less reductionism in biology education: students' views on the compatibility of science and religion**

*Authors* *Michael Reiss and Tamjid Mujtaba*

13.30:15:00 Lunch

16:00-20:00 Tours – social event

#### **Thursday July 5th**

Location: Facultad de Educación (<https://educacion.unizar.es/en>)

Paper Session 7a (Strand: 1. Students' conceptions and conceptual change)

9:00-10:00 *Chair: Xana Sá-Pinto*

*Location: 0.5( ground floor)*

**Title** **Context-dependency of beliefs in genetic determinism: Indications for a mind-body split?**

*Authors* *Johannes Zang, Tim Heemann and Marcus Hammann*

**Title** **Understanding of evolution through natural selection in university freshmen: a comparison between students graduating from secondary education in Flanders, Belgium and the Netherlands.**

*Authors* *Rianne Pinxten and Ellen Vandervieren*

**Title** **How to make evolution an operational concept to understand the world: learning with Darwin.**

*Authors* *Xana Sá-Pinto, Alexandre Pinto and Joaquim Bernardino Lopes*

9:00-10:00 Paper Session 7b (Strand: 5. Teaching strategies and teaching environments)

*Chair: Christine Knippels*

*Location: 0.6( ground floor)*

**Title** **Instructional efficiency in an outreach lab: Model constructors versus model viewers**

*Authors* *Julia Mierdel and Franz Bogner*

**Title** **No Escape: the rise of Escape Rooms in secondary biology education. What do teachers and students perceive as the educational potential of Escape Rooms in secondary biology education?**

*Authors* *Alice Veldkamp, Marie-Christine P.J. Knippels and Wouter van Joolingen*

**Title** **Bifurcated Domino Path Approach: the theoretical output of a ‘design research’ study**

*Authors* *Georgios Ampatzidis and Marida Ergazaki*

Paper Session 7c (Strand: 7. Environmental education)

9:00-10:00 *Chair: Franz Bogner*

*Location: 0.7( ground floor)*

**Title** **Using two theoretical models to measure environmental perceptions in earth education**

*Authors* *Constantinos Manoli, Bruce Johnson and Sanlyn Buxner*

**Title** **How Appreciation of Nature intervenes with the Major Environmental Values (2-MEV)**

*Authors* *Franz X. Bogner and Michael Wiseman*

**Title** **Diagnoses of teachers regarding students’ strategies when addressed as moral subjects in the context of ESD**

*Authors* *Anne-Katrin Holfelder*

Paper Session 8a (Strand: 5. Teaching strategies and teaching environments)

10:00-11:30 *Chair: Anat Yarden*

*Location: 0.5( ground floor)*

**Title** **Inconsistent representation of alleles' symbols in textbooks**

*Authors* *Michal Haskel-Ittah, Ravit Golan Duncan and Anat Yarden*

**Title** **Prepared to teach genetics in school? – Examination of beliefs about learning content and instructional practice as well as academic self-concept of prospective biology teachers**

*Authors* Kathrin Ziepprecht, Katharina Gimbel and Jaqueline Jäger  
**Title** Epigenetic literacy and the implementation of epigenetics in school biology

*Authors* Niklas Gericke, Birgitta Mc Ewen and Karin Thörne

**Title** Genetics contents and societal issues – what are the approaches the secondary school biology teachers use in their teaching?

*Authors* Tuomas Aivelo and Anna Uitto

**Title** Representations of gene models in Greek secondary school biology textbooks

*Authors* Akrivi Christidou and Penelope Papadopoulou

10:00-11:30 Paper Session 8b (Strand: 6. Teaching and learning with educational technology)  
*Chair: Konrad Schonborn*  
*Location: 0.6( ground floor)*

**Title** Using an Innovative Online Modeling Tool to Support Students' Modeling Practice

*Authors* Tom Bielik and Sebastian Opitz

**Title** Digitally Led Experiments - Results of an Evaluation Study with the App divox

*Authors* Monique Meier

**Title** Interacting with Digital Touch Tables to Explore the Biological Microcosmos

*Authors* Konrad Schönborn, Gunnar Höst, Henry Fröcklin and Lena Tibell

**Title** Effectiveness of digital versus traditional (paper-based) dichotomous keys for identification of woody species

*Authors* Gregor Torkar

**Title** Supporting students' freedom during mobile-aided fieldwork in a biology lesson

*Authors* Anttoni Kervinen, Anna Uitto and Kalle Juuti

10:00-11:30 Paper Session 8 c (Strand: 6. Teaching and learning with educational technology)  
*Chair: Ruth Amos*  
*Location: 0.7( ground floor)*

**Title** **Combining biology education & education for sustainability in preschool: Insights from the 2nd cycle of a design research study**

*Authors* *Maria-Christina Kasimati and Marida Ergazaki*

**Title** **Investigating the Short- and Medium-term Effects of a School Kitchen-garden Project on Elementary School Students' Environmental Conceptions**

*Authors* *Stella Petrou and Konstantinos Korfiatis*

**Title** **Learning in nature: primary school children develop through biological experiences which connect the curriculum**

*Authors* *Ruth Amos and Michael Reiss*

**Title** **The potential of using digital tools in an environmental education context to address pollinator conservation issues**

*Authors* *Mona Schönfelder and Franz X. Bogner*

11:30-12:00 Coffee Break

Poster Session 2a (Strand: 2. Students' interest and motivation & 3. Students' values, attitudes and decision-making)

12:00-13:30

*Chair: Beatriz Bravo Torija*

*Location: 0.5( ground floor)*

<b>Authors</b>	<b>Title</b>
Inga Desch, Christian Vollmer and Peter Wüst-Ackermann	Gender Differences in attitudes towards animals and nature
Sergio Calavia Lombardo, Beatriz Bravo Torija and M.J. Gil Quílez	Analysis of the contents of bioethics topics in Science Culture textbooks
Alexandros Amprazis and Penelope Papadopoulou	Attitudes towards plants: Evaluating the intensity of the "Plant Blindness" phenomenon in Greek primary schools.
Katarzyna Potyrala, Małgorzata Klys and Karolina Czerwiec	Biology students - future teachers' knowledge and attitudes towards migrations of species and diseases caused by insects
Stephanie Ohlberger and Claas Wegner	Differences between girls and boys regarding motivational changes due to bilingual modules in biology

Annette Scheersoi, Jonathan Hense and Lara Weiser	Multico: Promoting students' interest and their awareness of science careers
Nadine Großmann and Matthias Wilde	The effects of autonomy-supportive and controlling teaching behavior on students' goal orientations in biology lessons
Susana García-Barros, María Jesús Fuentes-Silveira and Paula Ramos-Fariña	Ideas about the model of what a living is being expressed by secondary school pupils and teachers in training

12:00-13:30

Poster Session 2b (Strand: 4. Scientific thinking, nature of science and argumentation)

*Chair: Ohad Levkovich*

*Location: 0.6( ground floor)*

<b>Authors</b>	<b>Title</b>
Sue Dale Tunnicliffe and Catherine Bruguere	Biology concepts and Pictorial Fiction Books. Do early years children comprehend?
Stephen Price, Paul Davies, Haira Gandolfi and Ralph Levinson	School students' engagement with contemporary biological research
Dagmar Frick and Claudia Nerdel	Acquisition of Mental Models in the Mathematical Modelling of Population Dynamics
Pablo Brocos and María Pilar Jiménez-Aleixandre	The optimization strategy as a scaffold for argumentation and decision-making about diets in secondary education
Anna Marbà-Tallada and Jordi Domènech-Casal	Promoting the role of data and scientific models in students' argumentation on socio-scientific issues through communication scaffolds
Torsten Kreher and Carolin Retzlaff-Fürst	Effects of Scientific Literacy on School Garden as an Extracurricular Place for Learning on Understanding of Nature of Science by Pupils of Secondary Classes
Martin Feike and Carolin Retzlaff-Fürst	Frequency of mathematical exercises in biology classes
Ohad Levkovich and Anat Yarden	Viewing molecular models of proteins via Jmol: Evaluating students' epistemic knowledge about models

Diego Armando Retana-Alvarado, María Marta Camacho-Álvarez, Bartolomé Vázquez-Bernal and Andrés Osborne-Rovira

Emotions of Costa Rican Secondary students towards the development of a research project

Poster Session 2c (Strand: 6. Teaching and learning with educational technology & 7. Environmental education)

12:00-13:30

*Chair: Maria Cristina Pansera de Araujo*

*Location: 0.7( ground floor)*

<b>Authors</b>	<b>Title</b>
Emanuel Nestler and Carolin Retzlaff-Fürst	Teaching Scientific Inquiry in Biology: an Intervention Study about Mentoring for Pre-Service Biology Teachers
Charalambia Lazaridou and Zacharias Zacharia	"Capturing" photosynthesis via mobile learning
Michal Topaz and Tali Tal	Inspired by Bioinspiration at the zoo: Three case-studies
Jennifer Schneiderhan and Franz X. Bogner	Students' attitudes towards biodiversity conservation
Arritokieta Ortuzar-Iragorri, Iñaki Sanz-Azkue, Aritz Ruiz-Gonzalez and Joserra Díez	The plant species repertoire of basque secondary education students and their interest in nature
Jenny Duarte, Edgar Valbuena and Maria Cristina Pansera de Araujo	Environmental education from the Biology class. Animal abuse as a fully encompassing content

13:30-15:00

Lunch

Business meeting

15:00-16:00

*Location: Conference hall (basement)*

16:00-16:30

Coffee Break

Poster Session 3a (Strand: 5. Teaching strategies and teaching environments)

16:30-17:30

*Chair: Manon Albert*

*Location: 0.5( ground floor)*

<b>Authors</b>	<b>Title</b>
Manon Albert and Marie-Claude Bernard	Teachers' views on integrating socially acute questions (SAQ) into biology classrooms: role of the curriculum and the organizational structure in Québec's colleges
M <sup>a</sup> -Jesús Fuentes-Silveira, Juan Rivadulla-López, Susana García-Barros and Cristina Martínez-Losada	Is biodiversity necessary in the ecosystem? A classroom experience
Maria Cristina Pansera-De-Araújo and Rúbia Emmel	The practice of research-training-action, basic education curriculum and textbook, in a biological sciences degree
Lissy Jäkel, Sabrina Frieß, Ulrike Kiehne and David Hergesell	Processes of professionalisation – Outdoor teaching and assessment of PCK
Elke Blodau, Lissy Jäkel and David Hergesell	Suitability of zoo animals for sustainability topics for primary school children

Poster Session 3b (Strand: 5. Teaching strategies and teaching environments & 9. Social, cultural, and gender issues)

16:30-17:30

*Chair: Evangelia Mavrikaki*

*Location: 0.6( ground floor)*

<b>Authors</b>	<b>Title</b>
Marlen Grimm and Carolin Retzlaff-Fuerst	Learning and teaching with rubrics (Kompetenzraster) - Development and evaluation of inclusive learning environments in biology classes to foster students' success and motivation
Emilio Costillo, José María Merino, Rocío Esteban, Javier Cubero, José Antonio Regodón and José Ramón Vallejo	Analysis of the pedagogical strategies used by prospective teachers to design nature field trips
Joanne Nicholl	Exploring pre-service biology teachers' experiences on a zoo trip
Diego Armando	Emotions of teachers in initial formation towards the

Retana-Alvarado, teachers of Experimental Sciences Didactics according to gender  
 María Ángeles De Las Heras-Pérez,  
 Bartolomé Vázquez-Bernal and Roque Jiménez-Pérez

Evangelia Mavrikaki, Approaching health issues and Europe's history and cultural heritage through differences in food and Nausica Kapsala and Apostolia Galani culinary representations in school textbooks

Poster Session 3c (Strand: 8. Health Education)

16:30-17:30

*Chair: Graça S. Carvalho*

*Location: 0.7( ground floor)*

<b>Authors</b>	<b>Title</b>
Graça S. Carvalho, Liziane Martins and Charbel El-Hani	The relevance of Biomedical and Socioecological approaches in school Health Education
Graça Carvalho, Paulo Mafra and Nelson Lima	Primary school health education: how children can learn about microbes and hands hygiene
Sarah Dannemann	Effects on primary and comprehensive school teachers' attitudes, knowledge, and self-efficacy of health education during their participation in an activity program in class
Eliane Gonçalves Dos Santos and Maria Cristina Pansera de Araújo	Study of sexually transmissible diseases in commercial films: contributions to health education in teaching training

Poster Session 3d (Strand: 10. Practical work and field work)

16:30-17:30

*Chair: Ángel Luis Cortés Gracia*

*Location: 0.4( ground floor)*

<b>Authors</b>	<b>Title</b>
Andrej Šorgo and Urška Cigler	Teacher assessment, grading and feedback: biology laboratory work in Slovenian secondary school
María José Sáez Bondía and Ángel Luis Cortés Gracia	How do pre-service teachers address tree and bush identification?
Sebastian Opitz, Jasmin Colakoglu and Ute Harms	First steps in Researching the International Biology Olympiad: Analyzing what IBO Exams Assess

	Beatriz Bravo-Torija, Beatriz Mazas-Gil, María José Gil-Quílez, Begoña Martínez-Peña and Nerea Idoipe- Gómez	Applying scientific skills in a mould experience in Primary Education: How could we prevent the moulds coming out in food?
17:30-18:30	Researchers' café <i>Location: 0.4( ground floor)</i>	
20:00-23:30	Conference Dinner Aura Restaurant <a href="https://aurarestaurante.com/contacto/">https://aurarestaurante.com/contacto/</a>	

### Friday July 6th

	<i>Location: Facultad de Educación (<a href="https://educacion.unizar.es/en">https://educacion.unizar.es/en</a>)</i>	
	Round table about <b>“Publishing in Biology Education Research”</b>	
9:00-9:45	Tom Ireland, Editor of <i>The Biologist</i> and Managing Editor of the <i>Journal of Biological Education</i> (Royal Society of Biology, UK), Kostas Kampourakis (University of Geneva, Switzerland) and Michael Reiss (University College London, UK)	
	<i>Chair: Marcus Grace</i>	
	<i>Location: Conference hall (basement)</i>	
	Key note 2: <i>Jesús Martínez de la Fuente</i>	
9:45-10:45	<b>Nanomedicine: New Challenges for Biotechnology</b>	
	<i>Chair: Maria José Gil Quílez</i>	
	<i>Location: Conference hall (basement)</i>	
10:45-11:15	Coffee Break	
	Paper Session 9a (Strand: 1. Students' conceptions and conceptual change)	
11:15-12:15	<i>Chair: Marida Ergazaki</i>	
	<i>Location: 0.5 (ground floor)</i>	
<b>Title</b>	<b>Exploring the role of person analogy in young children's reasoning about the biological world</b>	
<b>Authors</b>	<i>Marida Ergazaki, Aggeliki Dimitrakopoulou and Spai Alexandra</i>	

<b>Title</b>	<b>There and back again – a journey into undergraduate students’ tree thinking</b>
<i>Authors</i>	<i>Petra Korall</i>
	Paper Session 9b (Strand: 10. Practical work and field work)
11:15-12:15	<i>Chair: Carys Hughes</i> <i>Location: 0.6 (ground floor)</i>
<b>Title</b>	<b>Inquiry is NOT Only about Hands-On Learning: Insights into Inquiry-Based Science Education from Two Different Teachers Groups</b>
<i>Authors</i>	<i>Shani Zur, Tali Tal and Mahsa Tsaushu</i>
<b>Title</b>	<b>Proposal of a Model for Professional Development: Perspectives and Stages that contribute to the improvement of the practice of teaching biology</b>
<i>Authors</i>	<i>Eduardo Ravanal Moreno and Édgar Valbuena Ussa</i>
<b>Title</b>	<b>Field practices as a strategy in the teaching of biology and in the training of future teachers. A study at the universidad surcolombiana</b>
<i>Authors</i>	<i>Elías Francisco Amórtegui Cedeño, Olga Mayoral García-Berlanga and Valentin Gavidia Catalan</i>
	Paper Session 9c (Strand: 11. Research methods and theoretical issues)
11:15-12:15	<i>Chair: María José Gil Quílez</i> <i>Location: 0.6 (ground floor)</i>
<b>Title</b>	<b>Curriculum narrowing in the university entrance assessment in Biology</b>
<i>Authors</i>	<i>Francisco Luis Alda, María José Gil Quílez and María Jesús Rodríguez Yoldi</i>
<b>Title</b>	<b>In search of a notion of biological competence for primary education: A review of research articles</b>
<i>Authors</i>	<i>Jairo Ortiz-Revilla, Ileana M. Greca and Agustín Adúriz-Bravo</i>
.12:15-13:00	Closing ceremony
.13:30-15:00	Lunch

# KEYNOTES

## KEYNOTE 1

### **María Pilar Jiménez-Aleixandre**



*Universidade de Santiago de Compostela, Spain*

María Pilar Jiménez-Aleixandre is Ad Honorem professor of Science Education at the University of Santiago de Compostela, in Spain. Before completing her PhD about conceptual change on evolution, she was a high school teacher and served as science education coordinator for Spanish in-service teacher education. Her research focuses on argumentation, epistemic practices, critical thinking and socio scientific issues. She has published around 60 books and book chapters, among them the first volume about *Argumentation in Science Education* (Erduran & Jiménez-Aleixandre, 2008). She has also authored or co-authored about 70 papers in refereed journals in English, Spanish, French, Portuguese and Galician, among them some seminal work on argumentation in science education. She has participated in European Union funded projects about introducing argumentation and critical thinking in teacher education. She currently serves on the boards of *Science Education* (as co-editor of the Issues and Trends section), *Science & Education* and *Environmental Education Research*, among other journals. She is also an award-winning author of poetry and fiction, under the pen name of Marilar Aleixandre, and a member of the Royal Galician Academy or Real Academia Galega (RAG).

### **How to gather and analyse quality evidence about successful biology classrooms**

The paper discusses methodological issues related to classroom studies. Its focus is on innovative biology teaching, on examples of successful learning, with a double goal: 1) debriefing the processes leading to quality research studies and papers; 2) providing researchers and teachers with models, rather than focusing on the problems of unsuccessful teaching. Our approach is grounded on a sociocultural perspective, drawing from discourse analysis and interactional ethnography (Kelly & Green, 2018). Methodological issues are relevant, since most flaws in submitted manuscripts or research proposals relate to methods. In the context of qualitative studies, the overarching question we sought to answer is: Which is empirical evidence in qualitative studies? This is further broken down in the examination of how to ask robust research questions; how to plan an appropriate design in order to gather data; how to elaborate specific tools to analyse learning gains in biology and in scientific practices; how to present results and conclusions grounded in evidence; how to produce graphic representations of results. These issues are discussed with examples from classroom studies in Early Childhood Education (e.g. Monteiro & Jiménez-Aleixandre, 2016), and about socio-scientific dilemmas in high school (Brocos, Jiménez-Aleixandre, & Baker, in review), and teacher education (Jiménez-Aleixandre & Brocos, 2017). We suggest that in studies about practices and processes the evidence should be about participants' performances. Implications for research and school practice are discussed.

## KEYNOTE 2



**Jesús M de la Fuente**

*Instituto de Ciencias de Materiales de Aragón and CIBER-BBN,  
Zaragoza, Spain*

Jesús M de la Fuente is a Permanent Researcher at the Spanish National Research Council- Aragon Materials Science Institute (Zaragoza, Spain) and member of CIBER-BBN. He was a pioneer in the emerging field of Glyconanotechnology. His research was oriented to the vectorization of paramagnetic nanoparticles with biologically relevant carbohydrates to label and visualize brain tumors. In June 2007, Dr de la Fuente established the Nanotherapy and Nanodiagnostic Group at the Institute of Nanoscience of Aragon (University of Zaragoza, Spain). As principle investigator, he has received a European Research Council-Starting Grant for “Multifunctional Magnetic Nanoparticles: Towards Smart Drugs Design-NANOPUZZLE” (2010-2015), a European Research Council-Proof of Concept-HOTFLOW (2017-2018) and ERANET project “Multifunctional Gold Nanoparticles for Gene-Therapy-NANOTRUCK” (2009-2012), he is PI of a FP7-NMP “Nanotherapeutics for Antibiotic Resistant Emerging Bacterial Pathogens-NAREB” (2014-2018). He has actually 6 licensed PCT patents. He was awarded with the “Shanghai-1000 People Plan” in 2013 to be Chair Professor at Jiao Tong University (Shanghai, China).

### **Nanomedicine: New Challenges for Biotechnology**

Nanotechnology is considered by many to be the next technological revolution. Thanks to this technology, we can control materials at the nanoscale level and develop nanometric devices such as nanoparticles. Nowadays, there are many applications for these nanoparticles in very different fields such as electronics, communications, optics, chemistry, energy and of course also biology. However, why are these nanoparticles interesting from Biotechnology? Mainly because, due to this nanometric size, the matter acquires different properties, and new utilities arise from these materials. In addition, all the biomolecules are in this size range.

In recent years, many applications of nanoparticles have emerged in the field of Biology, whether they have been used to fluorescently label proteins, or to visualize organelles into cells with ultra-high resolution. In addition, the use of these "nanosystems" in the field of Medicine has led to what is now called Nanomedicine. Nanomedicine aims to use the advantages of these nanomaterials to develop drugs or diagnostic systems more effective than current ones. At present, it is intended to go a step further and ensure that the drug is specifically driven to the tissue or organ to be treated. If we managed to do this, we would be able to eliminate almost completely the side effects of the drugs. How far are these goals to be achieved? It is estimated that in the next few years, half of the pharmaceutical industry will be based on Nanotechnology. Currently there are many research teams around the world working in this field with a huge resources investment to achieve these goals.

So far, there is an enormous need for academics, teachers and researchers trained not only in nanomedicine synthesis, but also in the whole process of nanomedicine evaluation, such as safety, efficacy and regulatory issues. The need for specialized workforce skills in this area is getting more and more important in the last years due to the rise of nanotechnology products. Therefore, an innovative training approach is required, in order to cover the different processes that a Nanomedicine needs to experience before getting into market: rational design, formulation and quality assessment, safety and efficacy, both *in vitro* and *in vivo*. Furthermore, complementary training is also needed to comprise the barriers that can be found in the nanotechnology commercialization up to now: safety issues, regulation, manufacturing, standards and public attitudes and awareness.



# **ABSTRACTS**

**FOR PAPER AND POSTER PRESENTATIONS**

**Alphabetic order by the first author's surname**

# “Models in action”: Using scientific knowledge for social action to support science learning

*Idit Adler, Tali Tal, Irene Bayer, Jane Lee, Stephen Modell, Ella Greene-Moton, Toby Citrin and Joseph Krajcik*

**Keywords:** project-based learning, Culturally Relevant Pedagogy, social action, scientific practices, equity

**Type of presentation:** Poster

Making new and challenging approaches to science teaching accessible to all students requires implementation of effective teaching strategies that capitalize on learning opportunities while being aware of the demands that such approaches pose to non-dominant student groups. In this paper, we describe a new biology curriculum that uses Culturally Relevant Pedagogy (CRP) as a framework to bridge science learning, culture and communities, and support science learning for non-dominant student groups. The curriculum “Health in Our Hands: What controls my health?” is a ten-week project-based learning curriculum that focuses on the concept of gene-environment interactions through the phenomenon of Type II diabetes. The students use scientific knowledge gained through a constructive process of model development to engage in social action through community inquiry-based projects. We termed this structure “models in action”, and examine how this structure created a learning environment that supports science learning. We collected data from two consecutive enactments in 6th grade classrooms in a large high-needs urban district in a Midwestern state in the USA. Both qualitative and quantitative data was collected from teachers, students, parents, and community members. The data suggest that CRP domains were expressed throughout the curriculum and played a critical role in students’ learning: Both model construction and community projects engaged students in challenging learning opportunities to construct scientific knowledge and transform this knowledge into social action; both model construction and community projects supported cultural competence by emphasizing the importance of scientific capital, highlighting local funds of knowledge, and providing opportunities to engage and connect the scientific knowledge to students’ interests, experiences and community with pride and enthusiasm; last, the curriculum supported the development of a critical consciousness as the students developed and used their scientific knowledge to critically examine their environment and consider ways to improve their own and their community’s health through both individual and collective action. Our findings demonstrate how the scientific and social components of the models in action structure are crucial to create a learning environment that supports CRP strategies that augment learning opportunities for all students. Our work highlights how a carefully designed curriculum can support challenging approaches to teaching biology by providing opportunities for all students, with particular focus on non-dominant students, to learn science in a meaningful way.

# **Students' arguments and reasoning in genetics: dealing with the complex interactions between genotype and phenotype in the expression of animal diseases.**

*Noa Ageitos Prego, Laura Colucci-Gray and Blanca Puig*

**Keywords:** argumentation, modelling, genetics learning

**Type of presentation:** Oral

Previous studies on argumentation in genetics education point to the existence of deterministic views in the discourse of secondary school students when arguing on the causes of human biological states. This paper seeks to make a further contribution on argumentation in genetics education and on studies focusing on students' understanding of gene expression and deterministic positions. Biological determinism in the context of animal diseases has been under-explored in genetics education.

In the context of health issues, genetic determinism means understanding diseases in terms of cause and effect, whereby the genes are the principal cause, leaving no room for environmental factors. Hence genetics is treated and understood as separate from ecological and evolutionary factors, preventing further understanding of population dynamics, adaptation processes and further extending to wider questions related to inter-breeding and even migration. This paper presents data from an argumentation task about a genetically-related animal disease that engage students in the construction of arguments and critique supported by modelling exercises.

The research questions that drive the paper are: 1). How do students use the model of gene expression to argue about a disease with a genetic component after an argumentation and modelling-based instruction approach? 2). To what extent are students able to critique a deterministic model to explain a disease with a genetic component?

The study focuses on students' argumentation in five small groups (4 students) in a 11th grade classroom (N=20), while working on a task that requires students to interpret and use data to explain the cause of death of animals (pigs) during their transportation. Data collection includes audio and video recordings, students' written reports and the researcher field notes. The methodological approach is qualitative and draws from discourse analysis (Gee, 2015).

Students arguments are differentiated in two categories: 1) arguments that apply a deterministic model of gene expression and 2) arguments that apply a model of gene expression that considers the environmental factors shaping the selective expression of genes. However, none of the groups are able to critique a determinist model for explaining the animal disease.

# Genetics contents and societal issues – what are the approaches the secondary school biology teachers use in their teaching?

*Tuomas Aivelo and Anna Utto*

**Keywords:** socioscientific issues, context, genetics education, teaching sequence, human genetics, grounded theory approach, teacher interviews

**Type of presentation:** Oral

Understanding of genetic phenomena is an important part of 21st century scientific literacy. While socioscientific issues (SSI) are emphasized and impediments to considering SSI are widely studied, biology teachers remain resistant to adopt them. Far less is known about how teachers choose contents for their genetics teaching. We explored how teachers choose contents for biology courses that include learning on cells, heredity and biotechnology. We interviewed ten upper secondary school biology teachers. We asked which contents they perceive as the most important and studied specifically how they described teaching genetically modified organisms, human hereditary disorders and complex human traits. We used grounded theory approach to analyze the interviews to build a tentative model of variables influencing teachers' choices. Three main categories, development of phenotype, inheritance and continuity, and gene function were found. While teachers mentioned that SSI are important, they were never mentioned as the most important contexts. Teachers also differed in how they described teaching human-related contents: some embraced these while other described avoidance due to content-related (lack of examples, complexity, student misconceptions, emphasis on all organisms) and pedagogy-related issues (considering sensitive and controversial issues). We classified teachers' perceptions to Developmental, Structural and Hereditary approaches in genetics teaching. The approaches contained the perceptions of the most important contents and teacher inclinations towards teaching human genetics. The most experienced teachers leaned more to Structural, whereas less experienced teachers used more Developmental approach. The tentative model of teachers' choices included national-level factors, which were common to all teachers, school-level factors as the local context where teaching happens and personal-level factors. Our results concur with previous studies, that biology teachers' teaching is strongly affected by their identity as biologists, which was evident on how impediments to SSI were usually framed with content knowledge. Nevertheless, teachers' perceptions were strongly consequential to teachers' likelihood to discuss human genetics. Conversely to previous research, the less experienced teachers were most open for discussing human genetics. Our results further suggest that curriculum has an important position to encourage teachers to adopt SSI-oriented genetics teaching.

# Teachers' views on integrating socially acute questions (SAQ) into biology classrooms: role of the curriculum and the organizational structure in Québec's colleges

*Manon Albert and Marie-Claude Bernard*

**Keywords:** Higher education, teacher, biology, curriculum, organizational structure

**Type of presentation:** Poster

Breakthroughs in biotechnology pave the way for new possibilities in the study of life and bioengineering. These new possibilities can generate socially acute questions (SAQ) arising from debates in the construction of scientific knowledge and notable in the social media (Simmoneaux, 2003). For science educators, it is not always an easy task to address these SAQ in classrooms (Levinson, 2004; Simmoneaux, 2003). Our research aimed to understand how college biology teachers address SAQ in their classrooms and help students construct their critical thinking when facing these issues. We chose a focus group format and used an analysis framework based on an interactionist perspective to identify how teachers collectively consider and approach SAQ. We recruited six biology teachers, forming two focus groups, from four "collèges d'enseignement général et professionnel" ("cégeps" or general and vocational colleges) in the province of Québec. In Canada, CÉGEPS are a distinctive feature of the province of Québec education system. With universities, they constitute the province's higher education system, and the government does not require college teachers to have a degree in education. We analyzed the content of the focus groups' discussions and found that the participants voiced concerns about the science curriculum and the organizational structure of colleges. In this paper, we present the results. We grouped the issues raised by the participants into three themes: a) the science curriculum; b) the organizational structure; and c) the element of time. As trained biologists, the participants defended the legitimacy of biological contents of the curriculum, they were opened to interdisciplinary approaches, and they expressed the need for training in pedagogy. We think college teachers could benefit from a continuing education where SAQ related to the study of life are addressed and integrated as part of teaching practices. While there seems to be a general agreement that science education needs to move forward, there is an ongoing debate about the goals it should pursue concerning both the epistemological postures to be adopted and the type of training required by science teachers.

# Curriculum narrowing in the university entrance assessment in Biology

*Francisco Luis Alda, María José Gil Quílez and María Jesús Rodríguez Yoldi*

**Keywords:** Curriculum, Biology, Curriculum alignment, Curriculum narrowing

**Type of presentation:** Oral

University entrance tests are a major milestone in a student's educational process, especially to gain admission to high-demand degree courses such as Medicine or Biotechnology. A test design that does not conform to the objectives established in the curriculum leads to undesirable effects on students' educational progress to comply with validity, fairness and justice requirements.

Our work has sought to examine whether university entrance assessments in the field of biology have adequately represented the official curriculum. As result, we found significant differences between the evaluated and intended curriculum in most of the analysed dimensions.

# How the nutrition function of the human body is explained by elementary pre-service teachers

*Arnau Amat, Laura Martín and Isabel Jiménez*

**Keywords:** the human body, the digestive system, student teachers' conceptions, pre-service teacher education

**Type of presentation:** Poster

This study is an exploratory and preliminary research that was carried out in an elementary pre-service teacher science education subject. The main purpose of this study is to explore pre-service teachers' intuitive ideas about the nutrition function of the human body. Data was gathered from an open-ended questionnaire with two questions designed to explore the ability of student teachers to describe the anatomy of the digestive system and its interrelationship with other body systems. Our results suggest that elementary pre-service teachers have some anatomical misconceptions, but they experience difficulties when they have to interconnect systems, to build a complex explanation about the nutrition function.

# **Field practices as a strategy in the teaching of biology and in the training of future teachers. A study at the universidad surcolombiana**

*Eliás Francisco Amórtegui Cedeño, Olga Mayoral García-Berlanga and Valentin Gavidia Catalan*

**Keywords:** Field Practice, Teaching of Biology, Teacher Training, Professional Knowledge of the Teacher

**Type of presentation:** Oral

We consider Field Practices as a fundamental strategy in the teaching-learning process of Biology and in the training of future teachers in this field, especially in a country like Colombia, considered one of the most biodiverse in the planet. Despite this, studies on its contribution to the construction of the Teacher's Knowledge are scarce. The objective of this research is to characterize the contribution of Field Practices to the construction of this Professional Knowledge in future teachers of Natural Sciences. The sample is formed by a group of 27 students from the Universidad Surcolombiana (Neiva, Colombia). The training intervention consisted of a seminar developed during the second semester of 2016 and its evaluation consisted of a mixed study, longitudinal through content analysis, participant observation and application of a pre- and post-test, validated previously, analyzing the data through a t-student. The results allow emphasizing that at the beginning of the formative process, the students' conceptions approached a reductionist perspective of the didactic role of field trips. After the training exercise, which included the application of field practices designed with secondary school students (10-15 years) from schools of the Department of Huila, the future teachers presented a constructivist approach to the idea of Field Trips, framed in a more active role of students. The training activity allowed future teachers to conceive Field Practices as a fundamental strategy in the teaching of Biology and an important exercise in their professional growth and development.

# **Learning in nature: primary school children develop through biological experiences which connect the curriculum**

*Ruth Amos and Michael Reiss*

**Keywords:** ecology, connectedness to nature, primary, connected curriculum

**Type of presentation:** Oral

Whilst many of the benefits of learning beyond the classroom are well established in terms of environmental knowledge, attitudes and behaviours (Stern et al., 2014), there has been developing interest in the roles learners play in learning processes in nature. In addition, the potential for promoting connectedness with nature (Braun & Dierkes, 2017) associated with positive impacts on mental health and well-being for learners within an often stressful, high-stakes school assessment system is under scrutiny. Providers of short and longer term interventions in natural settings for people of all ages both in and outside formal education are attempting to understand the beneficial aspects. Our aim was to evaluate the quality and outcomes of ‘learning in nature’ events in a variety of environments. We report outcomes from six distinct programmes to support primary school children’s learning about ecology and, as a result, cross-subject skills. Using a qualitative, interpretative design to capture dialogue, actions and perceptions, we observed events and activities led by expert facilitators. The research methods used non-participant observation and interview conversations with participant children (7-11 year olds), accompanying teachers, teaching assistants, parents and WT facilitators. In total, 172 children formed the sample. Our findings reveal children developing and applying ecological ideas and skills in creative, independent ways. Children interacted with and explored the natural world which supported their learning of biology, literacy and life skills. Teachers and parents confirmed that learning in nature also led to children’s increased self confidence, self esteem, peer collaboration and motivation to learn. This was particularly evident during the longer Forest School-type programmes. Evidence for teachers adopting learning through nature strategies in the school curriculum was also seen. We therefore suggest such programmes enhance children’s learning of ecology, as well as connecting the curriculum across subjects such as literacy and developing broader life skills.

# **Bifurcated Domino Path Approach: the theoretical output of a ‘design research’ study**

*Georgios Ampatzidis and Marida Ergazaki*

**Keywords:** design research, design theory, Balance of Nature

**Type of presentation:** Oral

This paper reports on the theoretical output of a ‘design research’ study concerning the design of a learning environment (LE) that aims at replacing the idea of the ‘balanced’ nature with the idea of the ‘resilient’ one; the former suggests a predetermined order and stability, whereas the latter favors contingency over purpose. Our focus is set on exploring whether it is feasible to come up with an empirically tested ‘theory’ of teaching/learning about contingency in nature while designing our LE. So, we are particularly concerned with which this ‘design theory’ may be, and whether it works well enough in the context of its articulation. The study included an ‘exploratory phase’ (EP) and three ‘research cycles’ (RC1-3). The participants were 1st-year educational-sciences’ students (NRC1=41, NRC2=34, NRC3=44), who had basic knowledge of ecology, computer-use and group-work, were attending an optional ecology-course, and volunteered to participate. What they had to do was to collaboratively explore computer-models of ecosystems’ behaviour to changes, to understand the underlying contingency. In the EP, we defined learning objectives and design criteria that informed the 1st version of the learning environment (LE1) which was driven by the ‘global’/overall question of how ecosystems may function; this was answered by going through inter-connected ‘local’/partial questions; and these by going through ‘scaffold questions’ within worksheets linked to computer-models of ecosystems’ behaviour to changes. This ‘scaffolded’, ‘problem-posing’ design had to take a less linear form due to the unsatisfactory results of the RC1-case study: students shifted from the ‘always’ to the ‘never’ ‘recovering nature’. To become effective in highlighting ecosystems’ contingent/uncertain behaviour to changes within LE2, we introduced two-version computer-models for each change students had to explore. This ‘bifurcated’ version of the initial design, which made it through RC2, was re-tested in RC3 and thus accounts for the key-features of the study’s theoretical output. The resulting ‘design theory’ is the ‘Bifurcated Domino Path Approach’ (‘BDPA’). The design of LEs addressing the idea of contingency in ecosystem’s behaviour can integrate ‘BDPAs’ with several (a) ‘forks’, where some peer-groups explore one version of the target-phenomenon and others an alternative one, and (b) ‘meeting points’, where they all share their different, contingency-indicating conclusions. To argue for the ‘BDPA’s functionality in the context of its articulation, we draw upon the results of RC3, mixed-model case study, showing that the ‘BDPA’-based LE3 helped students with the idea of contingency. The ‘BDPA’s transferability to other contexts is worth-discussed, too.

# **Attitudes towards plants: Evaluating the intensity of the "Plant Blindness" phenomenon in Greek primary schools.**

*Alexandros Amprazis and Penelope Papadopoulou*

**Keywords:** Plant Blindness, Attitudes, Primary school

**Type of presentation:** Poster

It is well known, that plants are the cornerstones of the life circle upon Earth and contribute essentially to human life. However, people don't seem to find them interesting and in their everyday life rarely notice or value the flora around them. When a child has the opportunity to spend time with an animal or a plant, most of the times it chooses the animal. Students prefer to study more about animals than plants and furthermore, they seem to learn more easily about animals. This phenomenon is called plant blindness and according to the literature, the discrimination between human and animal external characteristics as well as the reduced emphasis on plant life in educational systems worldwide, are listed among its top causes.

In order to evaluate the intensity of plant blindness, we used a self constructed questionnaire. The present study is focused on the development and the first results of this research instrument. The main questionnaire's dimensions were originally determined by the theoretical framework of plant blindness and preliminary interviews with several students. Prior to the final implementation, pilot-testing of the questionnaire took place, involving students with the same characteristics as the children of our sample. During the pilot study a reliability analysis was conducted and the Cronbach's alpha score was 0.84. The research instrument consisted of questions that examined interest in plants and in animals, along with a particular question regarding the recognition of plants as living things. The interest rates were determined through a 5-point Likert-type scale. One thousand forty eight (1048) primary school students participated in our final implementation. The participants came from both rural and urban areas of Greece in order to clarify whether there is a statistically significant difference between these two populations in regard to the plant blindness phenomenon. According to the main results, the participants demonstrated a higher preference for animals. This was recorded for all questionnaire's items such as "preference for taking care plants/animals" or "spending time in a garden/zoo". Additionally, almost one third of the participants didn't include any plant in the list of five living things. Our results elucidate the low interest rates regarding plants as well as the inability to recognize them as "life-givers". These findings have also been recorded by researches in other countries and can be found in the literature.

# **Topic-specific didactics in biology in higher education – easily achieved but absent in biology faculty teaching**

*Kristina Andersson and Annica Gullberg*

**Keywords:** Biology didactics, Biology faculty, Higher education, Pedagogical Content Knowledge (PCK)

**Type of presentation:** Oral

Science education research has predominantly focused on students and student learning, and to some extent on school teachers and teacher education students. However, research about teacher educators is sparse. In many higher education institutions in Sweden the student teachers study science in the science departments, which means that teacher educators are scientists and often researchers within their respective fields. The aim of the project is to explore the borderland between the academic biology discipline, teacher education and the teaching of the school subject biology. Which conceptions in and about biology and its practices are implicitly and explicitly communicated in higher education? The empirical material was collected by shadowing and interviewing three professors and one senior lecturer in biology (physiology, evolutionary biology, microbiology and botany). They teach both science courses within teacher education (upper secondary school) and other educational programmes (e.g. the Bachelor or Master programme in biology). The data consists of field notes, audio-recorded and transcribed interviews with faculty and material used within teaching. We used Gee's Discourse Analysis (Gee 2005) to analyse our empirical data. Discourse models refer to 'theories' (storylines, images, explanatory frameworks) that people hold, often unconsciously, and use to make sense of the world. Using Gee's Discourse Analysis two discourses emerged in this biology context; Biology Content & Practices Discourse (BCP) and Didactics (D). A third discourse, Topic-Specific Didactics (TSD) derived from science education research but was not found in the empirical data. However, considering the teaching activities conducted by these highly skilled faculty, TSD is achievable. This could be accomplished if science faculty increases their awareness of the topic-specific didactics and thereby enhance teacher students' professional skills.

# Learning using contradictory texts promotes students' critical thinking

*Moriah Ariely and Anat Yarden*

**Keywords:** Critical Thinking, Argumentation, Adapted Primary Literature, Popular articles, Text genres

**Type of presentation:** Oral

The ability to make evaluative judgments about the validity of science-related media reports and their implications on people's lives and the society was recently accepted as an important aspect for developing students' argumentation skills and critical thinking. Popular articles often do not reflect the core attributes of authentic scientific reasoning. Nonetheless, most students will read popular articles in their future lives. Adapted Primary Literature (APL) articles are designed to enable the use of scientific research articles in high school. As opposed to popular articles, the APL authors adapt Primary Scientific Literature (PSL) articles while retaining the authentic characteristics of the PSL articles and taking into account the practical reasoning involved in producing scientific knowledge.

In this study we analyzed 10th grade students' ability to critically assess a popular article after reading two contradictory texts and engaging in an argumentation activity (n=83). Students participated in an intervention which included; instruction about argumentation fallacies, a reading activity of two contradictory texts, and a debate. One group of students (group A, n=37) was given two contradictory popular articles, and a second group of students (group B, n=46) was given two contradictory APL articles. All students were given a popular article on a different topic (pre-questionnaire) before the intervention and a second, different popular article, after the intervention ended (post-questionnaire). Students were asked if they accept the popular articles' claims and why. Critical questions and fallacies that students found in each article were analyzed.

A significant improvement was found in students' ability to critically assess the articles in both groups. When comparing the groups, no significant difference was found between students' ability to critically assess the article in the pre-questionnaire. However, group B students' ability to critically assess the article significantly improved in the post-questionnaire compared to group A. These results suggest that engaging students with contradictory articles and argumentation may have a positive effect on their ability to assess the claims made in popular articles. Nonetheless, if presented with research articles, readers may gain a clearer view of what is actually involved in research. This may explain the significantly improved ability of the students in group B (APL) to critically assess the popular article given to them in the post-questionnaire. We suggest that APL articles may serve as models of scientific reasoning and communication, and help to promote students' critical thinking.

# **A short intervention that promotes the abstract reasoning scheme improves ninth graders' achievements in photosynthesis**

*Reuven Babai and Esty Fridman*

**Keywords:** Photosynthesis, Cognitive acceleration, Intervention, Abstract reasoning scheme, Piagetian cognitive levels

**Type of presentation:** Oral

Photosynthesis is regarded as a difficult subject in the biology curriculum. Researchers have pointed out that difficulties in photosynthesis might be related to the fact that this is an abstract subject that includes processes, transformations and abstract principles. The current study addresses the difficulties in photosynthesis from the cognitive development perspective. According to Piaget, abstract thinking develops during the formal operational stage. Therefore, students' low Piagetian cognitive levels could explain, at least in part, difficulties in photosynthesis. We addressed these difficulties through a short intervention of three sessions taken directly from the CASE program (Cognitive Acceleration through Science Education). We explored whether such intervention that focuses on acceleration of the abstract reasoning scheme would have a positive effect on ninth graders' achievements in photosynthesis.

Taking part in the study were 146 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 photosynthesis was taught 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 a posttest exam in photosynthesis was administered post-intervention.

The findings indicate that the short CASE intervention had a significant positive effect on students' achievements in photosynthesis. In line with the study rationale, further analysis revealed that the significant benefit of the intervention took place in the pre formal operational Piagetian levels (the concrete operational level, and the transition stage from concrete to formal levels).

Overall, the study showed that the short intervention that was aimed at accelerating the abstract reasoning scheme by using three CASE sessions has a positive effect on students' academic achievements in photosynthesis. In addition, we suggest that science educators should pay more attention to limitations related to students' cognitive levels when addressing scientific topics in school.

# Persuasive effects of role-play about a socio-scientific issue

*Melanie Basten and Matthias Wilde*

**Keywords:** argumentation, bioethics, health education, teaching methods

**Type of presentation:** Oral

Organ shortage is a societal problem of high interest. Therefore, organ donation is a socio-scientific issue that needs consideration. In German schools, decision-making according to the educational standards for Biology (KMK, 2004) comprises rational weighing of different perspectives and aims at responsible citizenship. Furthermore, education on organ donation should present arguments in favour and against donation and the decision to donate should be informed and self-determined. A common teaching method for ethical topics is role-playing. The aim of our study was to investigate whether the effects of role-playing on attitude and behaviour (completing an organ donor card) depended on the opinion of the performed character or the extent of absorption into the role-play. A study by Green & Brock (2000) suggests that persons who are strongly transported into a narrative change their opinion more than persons who are less absorbed. This might lead to a behaviour change (Ajzen, 1991). Studies by Lohaus (1984) and Harvey & Beverly (1961) found that persons tend to change their opinion into the direction of the character that was performed or merely prepared for a role-play.

The hypotheses and research questions are:

H1. Students that are strongly transported into the role-play change their attitude to a greater extent than students that are not that strongly transported.

Q2. Do students that are strongly transported into the role-play more often sign an organ donor card than students that are not that strongly transported?

Q3. Are students that are assigned a character with a positive or a negative opinion equally transported into the role-play?

H4. The students' attitude changes in direction of the performed or prepared character's opinion independent of the students' attitude before the lesson.

German students (N=256; age: M=16.9, SD=1.5; 68% female) were taught about organ donation in a 90-minute lesson (Stümmler, Basten, & Wilde, in press) containing a slide-presentation about facts and a role-play. One week before and after the lesson, respectively, the students filled out a questionnaire on their attitude, behaviour and transport into the role-play.

Our results show that transport into a role-play did not change students' attitude or behaviour differently (H1 and Q2). Furthermore, performing or preparing a role-play (cf. Harvey & Beverly, 1961) with an assigned character did not influence the students' transport or attitude differently (Q3 and H4). Thus, a role-play provides similar preconditions for all students and can therefore be used as a learning method when covering organ donation as a socio-scientific issue.

# Contingency in Peer Scaffolding when Addressing Socio-scientific Issues in Biotechnology

*Birgitta Berne*

**Keywords:** SSI, argumentation, peer scaffolding

**Type of presentation:** Oral

Although policy and research in science education suggests that students learn best when engaged in discussions about socially relevant issues, less is known about how this actually happens in the classroom. This paper reports on a research project in a secondary school in Sweden, which examined the processes taking place in a peer-group discussion during a unit focussed on the desirability of universal DNA registers. Prior to the students' (14-15 years old) discussions varied prompts were used to highlight different aspects of the issue. In addition, students were given time to search further information themselves. Data were collected through students' own video recordings of the discussions. The results suggest that the notion of scaffolding is relevant for analysing students' dialogical argumentation and for understanding the interactions in a group where no student appears to be more knowledgeable than the others. This study shows that students collectively may contingently scaffold each other to make more reflective arguments. Students support each other in affect, metacognition and cognition with the result that students start to structure their arguments by connecting scientific data and qualifiers to their claims. Furthermore, students begin to consider alternative perspectives and recognise challenges to their own position. It seems as teachers, by motivating and framing SSI discussions in science education, can reduce their authoritative presence, hence the work has implications for the classroom and thus for continuing profession development and teacher education.

# Using an Innovative Online Modeling Tool to Support Students' Modeling Practice

*Tom Bielik and Sebastian Opitz*

**Keywords:** Systems, Modeling, Models, Simulation, Project-based learning

**Type of presentation:** Oral

Scientific modeling is a key practice that engages students in making sense of phenomena, solving problems, and communicating scientific knowledge. Scientists and engineers use models to explain complex systems, and students should have opportunities to develop their modeling practice in science class. The modeling practice includes building models that represent relationships between components in a system, using models to explain and predict phenomena, evaluating models based on peer critique and evidence-based reasoning, and revising models based on new findings. Modeling knowledge comprises of understanding the nature of scientific modeling, the purpose, function and limitations of models, as well as the different types of models that are used to make sense of phenomena.

In this paper, we examine how using an online computational modeling tool, designed to engage students in building, using, revising, and sharing models to investigate relationships between variables within a system, can contribute to the development of students' modeling practice. We present and discuss findings from a classroom enactment of a middle school biology unit about water quality that integrated the modeling tool. Preliminary findings show that students' models progressed in their complexity and sophistication during the enactment, that students' modeling knowledge developed to a more complete understanding of the nature of scientific models and the purpose of modeling, and that students' abilities to construct, use, revise, and share models developed following the enactment of the unit. Altogether, these results indicate that using a computational modeling tool can contribute to the development of students' modeling practice.

# Suitability of zoo animals for sustainability topics for primary school children

*Elke Blodau, Lissy Jäkel and David Hergesell*

**Keywords:** Education for Sustainable Development, Zoo. Primary school

**Type of presentation:** Poster

All around the world, zoos offer educational programs targeted at children of all ages. Few research studies exist that examine their contribution to the objectives of Education for Sustainable Development (ESD). This study aims at bridging that gap by evaluating a sustainability program that has been recently established by a local Zoo's school - it consists of two 90-minute zoo tours guided by zoo rangers, linking key sustainability topics (e.g. plastic waste, deforestation) to specific zoo animals (e.g. coastal birds, tigers).

Due to the complexity of the topic at hand and the young age of the target group, a qualitative research design was selected. Research methods included participatory observations (capturing children's reactions during the program) and guided interviews (with zoo rangers conducting the tours). A thorough evaluation of the data (covering 40 kindergarten and primary school children and four zoo rangers) following a qualitative content analysis approach showed that zoo animals proved to be effective means of communication for key sustainability topics. Relevancy could be most increased if i) the connection of a given zoo animal and sustainability topic was easy to comprehend for children, and if ii) the barrier to action was low enough for the children. The detailed analysis of six program themes (zoo animal/sustainability topic - connections) showed that children are a suitable target group for ESD. The program worked best for primary school children, however, due to their increased cognitive capabilities compared to kindergarten children. The study shows that the combination of emotion (via zoo animals) and cognition (sustainability topics) worked well. More research, however, needs to be carried out examining the long-term effects of such programs (e.g. recall performance). In addition, the role of parents and teachers in propagating ESD objectives should be further evaluated.

# **What timss tells us about education for sustainable development - a comparative study between biology and science teachers in Sweden.**

*Jelle Boeve-De Pauw and Niklas Gericke*

**Keywords:** ESD, whole-school approach, preparedness, biology teachers, TIMSS

**Type of presentation:** Oral

The implementation of Education for Sustainable Development (ESD) in formal education is an arduous process. A much reported issue is that teachers do not perceive ESD as part of their task. As ESD should be implemented through whole-school approach this is identified as one of the major barriers to successfully bringing ESD into formal education. The current study uses the most recent Swedish TIMSS data Sweden for grade 4 classroom teachers, and for grade 8 biology and science teachers to answer three questions: (1) How well prepared do teachers feel to teach ESD? (2) According to teachers, is ESD supported in/by the whole school? (3) How often do teachers participate in ESD professional development? Using data from over 1000 Swedish respondents, the study shows that elementary and science teachers feel ill prepared for ESD. Biology teachers in grade 8 feel most prepared, but their mean score is also below the value 2 (indicating that they do not even feel 'somewhat' prepared). Our study also reveals that students are not very involved in the implementation of ESD. This is problematic since ESD focusses on their participation. While PD rates are low for all teachers in the sample we see that when grade 4 and grade 8 science teachers do participate in such programs they feel better prepared to bring ESD into their classroom. At the same time we have to underscore that across PD topics in TIMSS, ESD is at the lowest level (around 13%, with other topics averaging 25 to 45%). Yet, these results show that PD is key to the successful implementation of ESD.

# How Appreciation of Nature intervenes with the Major Environmental Values (2-MEV)

*Franz X. Bogner and Michael Wiseman*

**Keywords:** environmental education, education for sustainable development (ESD), attitudes, outreach education evaluation

**Type of presentation:** Oral

When monitoring the long history of environmental attitude-sets, the 2-MEV model with its two higher order factors: Preservation (PRE) and Utilization (UTL) provides a valid empirical frame, repeatedly and independently confirmed and currently worldwide applied in 28 languages. PRE measures preferential attitudes towards conservation of nature, UTL does with attitudes towards exploitation of nature. Utilizing, however, may point to a double meaning, as the positive aspect of “using” nature currently is not included. Consequently, we added the existing “Appreciation of Nature” (APR) scale, which however was developed for RASCH-based approaches and not optimized for factor-analysed approaches. The complete test (PRE, UTL and APR) was applied to an Irish sample to 289 secondary school students (age:  $M = 14.3$  years). To reduce the number of items, we selected from the original 3x10-item battery a 21-item-set. Principal Component Analysis with subsequent oblique rotation using Promax yielded a clear three-factor solution, with UTL and PRE orthogonal, and APR positively correlated with PRE ( $r = .283$ ) with an interfactor angle of  $81.7^\circ$ . Thus, all three domains showed a clear structure even on the basis of the shortened battery, which makes applications easier for educators when planning environmental program logistics: As appreciation of nature is known to address an important facet for reaching individual behavioral levels, evaluation strategies may need to capture this facet, too. Application of our short scale may provide the necessary information about individual preferences and due to its suitable short item number may help to adjust program contents to individual needs.

# **Applying scientific skills in a mould experience in Primary Education: How could we prevent the moulds coming out in food?**

*Beatriz Bravo-Torija, Beatriz Mazas-Gil, María José Gil-Quílez, Begoña Martínez-Peña and Nerea Idoipe-Gómez*

**Keywords:** Living Beings, Primary Education, Scientific skills, Inquiry

**Type of presentation:** Poster

Working in Sciences in Primary Education classrooms can be motivating for students if we start from real experiences that involve them. The main aim of this proposal is related to the chance of the children to develop science skills through a practical experience with moulds. In particular, the research question is: How students apply scientific skills such identification of variables, discussion of results or coming to conclusions while carrying out an inquiry project about moulds? The participants are 75 2nd grade students from three different classes who have developed an inquiry activity about moulds. The experience starts when they found a mouldy mandarin in the classroom, and after thinking about that, they consider their own research question: “how could we prevent the moulds coming out in food?” In order to solve it, they decide to carry out an investigation in which they take into account the different aspects that are needed for the moulds to live in a bread loaf, or in other words, the variables they need to promote or to avoid the growth of moulds in the bread: light, live inside or outside a bag, temperature, toasted or not-toasted bread, considering a control sample in every case, just to compare the bread loaf in ‘normal’ conditions and being affected by the conditions related to the corresponding variable. Data collection of this paper includes the transcription of the students’ video recordings. The results show that this activity has been useful not only to develop scientific skills such as observation, making hypothesis, investigation design, data collecting, coming in conclusions or communication of results, but it also helps the students to modify their conception about moulds, considering them as living beings, recognising their needs and features.

# The optimization strategy as a scaffold for argumentation and decision-making about diets in secondary education

*Pablo Brocos and María Pilar Jiménez-Aleixandre*

**Keywords:** Argumentation, Decision-making, Diets, Sustainability

**Type of presentation:** Poster

Argumentation about Socio-Scientific Issues (SSI) involves the consideration of several dimensions, pieces of information and viewpoints (Aikenhead, 1985), as well as the articulation of evidence and values (Kolstø, 2006). Recently, several studies addressed the environmental impact of diets (Stehfest et al., 2009; Tilman & Clark, 2014), proposing a dietary shift towards vegetables for environmental and public health reasons. Our study examines secondary students' arguments and decisions in the context of a sequence about the dilemma between vegetarian and omnivorous diets. The sequence design incorporated the optimization strategy (Papadouris, 2012) as a scaffold for the decision-making process, which involves three steps: (1) quantitative evaluation of the appropriateness of each option regarding five criteria; (2) relative weight assignment to each criterion; and (3) calculation of the overall score for each option. The research questions are: (a) How do secondary school students (n=32) evaluate the appropriateness of diets according to five criteria and which relative weight do they explicitly assign to each criterion in the decision-making process? and (b) How does the optimization strategy promote the argumentation and decision-making processes about diet choices? The students evaluated the omnivorous diet as more appropriate according to the economic and the cultural-personal criteria, whereas they considered the vegetarian diet better from an environmental and ethical viewpoint. They considered the nutritional aspects as the most relevant for making a decision about diets, whereas the cultural-personal aspects were regarded as the least important. The preliminary results suggest that the optimization strategy is effective for promoting argumentation and decision-making about this SSI, as well as reflection about these practices, although with limitations regarding its potential for revealing the values involved in the decision-making process. The results of the study highlight the necessity of promoting the explicit reflection about SSI and about the potential conflictive relations between the values involved in such issues, as well as the need of reaching compromises for a responsible decision-making.

# Analysis of the contents of bioethics topics in Science Culture textbooks

*Sergio Calavia Lombardo, Beatriz Bravo Torija and Maria José Gil Quílez*

**Keywords:** scientific culture, bioethics, textbooks, contents, scientific literacy

**Type of presentation:** Poster

Jarman and McClune (2007) point out that to get citizens critical to scientific-technological development, students should develop the skills needed to analyze socio-scientific problems by using science and technology content knowledge in ethical contexts. Working with bioethics topics could prepare future citizens to understand the complex relations between science development and society, enabling them to participate in public discussions about these topics. Despite their importance, in the Spanish educational system it is difficult to find programs of natural science that include bioethical problems. The only exception is Scientific Culture. Although, there are many contributions in which textbooks are analyzed, not much is yet known about how bioethics topics have been addressed in them. Therefore, this proposal aims to examine which bioethical contents appear in five textbooks of Scientific Culture and how they are addressed. The steps for the analysis are a) the location of paragraphs dealing with bioethics topics; b) the establishment of a system of categories ad hoc based on the bioethical contents taking part in the Curriculum; and c) the identification of this categories in the analyzed books, differentiating between whether they appeared or not, and the percentage in which they did with respect to the total content of the book, and the didactic objective they pursue.

The results show that there is a heterogeneity of results between different books and a low percentage of bioethical content in them. For instance, three are books (1, 2, and 5) that more than 10 categories are addressed. Book 4 addresses 4 of the 14 categories, and book 3 only 3 of them. Regarding the bioethics content addressed in each book, the health issue is the most discussed, then genetics, finally socio-scientific controversies and ethics in scientific research.

Regarding how the content is addressed, Book 1 and 3 develop it only in an expository way. Book 2 stands out for the proposal of scientific debate and science and society. Book 4 focuses on the development of critical capacity in science and includes news, film and literature. Finally, book 5 proposes a debate and thought section, linked to the main curricular competences.

On the basis of these results, a deeper analysis is necessary to understand the reason for the quantitative differences identified in the study and also to understand which of the books promote a greater students' argumentation and critical thinking.

# The floral diagram as a didactic resource

*Beatriz Carrasquer Álvarez, Adrián Ponz Miranda and M<sup>a</sup> Victoria Álvarez Sevilla*

**Keywords:** Didactic of Biology, Botany, Flower, Floral Formula and Diagram

**Type of presentation:** Poster

Studies conducted in recent years have been pointing out an alarming diminution in interest of young people in science and mathematics studies. According to recent reports from the European Commission, a reorientation of the pedagogy of science education in schools, introducing research-based methods, would increase students' interest in science.

**Objetives**

- (1) To study how the flower concept (reproductive system/alive organism) and its components are taught in pre-university education.
- (2) Analyze the didactic value of the diagram and the floral formula to learn the flower concept.

To teach the flower concept, in the course "The Science of Nature in Early Childhood Education" of the Degree of Teaching in Early Childhood Education (DTECE), during the four academic courses (2012-2016, total students = 371) we used the floral diagram with real flowers and its formula. During the 2015-2016 academic year, they were asked how they had learned that biological term in previous educational stages, and how they valued their learning through the use of the manipulative resource presented here.

94% of the students stated that they had never used a real flower before to learn the concept and 92% of the students agreed to use the floral diagram as a resource with their own students.

98% of the students correctly identified the parts of the plant organ, using this resource. Main errors found were: incorrect location of verticilos (1%), obviating some of them or incorrect writing of the floral formula (0.5%, respectively).

All the students assumed that this knowledge is better acquired through this manipulative methodology, than with the traditional method of images of the traditional texts provided by publishers. As many studies on Didactics of Experimental Sciences suggest, learning through manipulative research experiences is more effective and motivating than through traditional master classes, as our results reveal. It is advisable to use these didactic techniques in the learning of biological concepts by the teachers in formation, to facilitate their future application in the classroom.

# The relevance of Biomedical and Socioecological approaches in school Health Education

*Graça S. Carvalho, Liziane Martins and Charbel El-Hani*

**Keywords:** Literature review, Health promotion, Health approaches

**Type of presentation:** Poster

Studies on school health education are still relatively scarce as compared to other biology teaching issues. Some works have focused on the dominance of the biomedical approach and the need to encourage health promotion in textbooks and in teaching. The classical biomedical approach to health, taken as a mere absence of disease, has a limited vision of health, with implications for its understanding by teachers and students, and especially for an effective construction of individual and collective healthy practices. A possibility to overcome these difficulties is complementing the biomedical approach with another health approach to surpass its limitations. The present study intended to present a critical review of the literature aiming at analysing the theoretical and practical indicators that differentiate health approaches and so identifying the most appropriate ones for school health education.

The study corpus consisted of articles published in peer review scientific journals. Four databases were used, two in English (Scopus and ERIC) and two in Latin language (LILACS and SciELO). All abstracts of the obtained 5717 articles were read but only 974 appeared to discuss theoretical health aspects or health practices. Of these, 644 were excluded because they were in books, proceedings or thesis. Other 161 were eliminated because they were repeated articles or not appropriate to the study, as they did not discuss different ways of thinking and acting in health. The final 169 relevant articles were fully analysed.

Five health approaches were identified: religious, biomedical, ethnomedical, behavioural and socioecological. Biomedical and socioecological approaches were identified as presenting very distinct characteristics, the former being more traditional and strongly rooted in the modern technological society and the latter of multidimensional features and still in progress.

School health education can benefit from the recognition of these two approaches to be used complementarily: biomedical approach with emphasis on diseases and prevention; socioecological approach giving students the opportunity to reflect on multifactorial aspects influencing their own health and so empowering them to exercise their healthy choices as free citizens and promoters of their own health and of their community.

# Primary school health education: how children can learn about microbes and hands hygiene

*Graça Carvalho, Paulo Mafra and Nelson Lima*

**Keywords:** Health education, Primary school, Microbes, Experimental activities

**Type of presentation:** Poster

Today's society requires that citizens have increasingly scientific training adapted to the new demands of a globalizing and technologically advanced world. Therefore it is necessary to adjust the curricula and teaching methodologies so that scientific training can be applied to real and current situations of pupils' personal and social lives, thus contributing to improve their scientific literacy. The experimental teaching of science is seen as an effective methodology facilitating the development of pupils' manipulative and reasoning capabilities, allowing a better understanding of the world around them. In order to promote experimental teaching on microbes in primary school, a proposal for health education focused on the topic hand hygiene was developed. This practical activity was tested with sixteen students of the 4th grade and focused on the question-problem: Why should we wash our hands before eating?

The teacher implemented the experimental activity by promoting intense critical thinking about pupils' predictions, their observations and answers to the question-problem. The pupils' experimental procedure document served as a guide and as a notepad, having the following structure:

- a) "Problem-question": initial question to be answered at the end of the activity;
- b) "Before the experience": students registered their predictions;
- c) "Experience": some specific procedures to be followed and designated spaces for pupils recording their observations;
- d) "After the experience": reflection on their observations (and their records) by comparing them with the initial predictions, as well as the registration of the answer(s) to the question-problem.

With one washed hand and another unwashed, one pupil per group rubbed two plates with medium and, after two days, observed and counted the number of colonies formed. Results showed that pupils came to recognise that they have bacteria on their hands and verified the effectiveness of a reduction in the handwashing process. The teacher promoted pupils discussing about their results so that they realized that bacteria can be responsible for potential diseases, especially if they do not wash their hands before meals. It was concluded that this activity can help children, as early as at the primary school, to understand what microorganisms are and the healthy reason for hand hygiene, being more than just a rule to comply.

# Representations of gene models in Greek secondary school biology textbooks

*Akrivi Christidou and Penelope Papadopoulou*

**Keywords:** textbooks, biology, secondary school, historical models, gene, gene function

**Type of presentation:** Oral

Textbooks play a crucial role in teaching science as the quality of didactic transformation and the scientific accuracy of the content determines their pedagogical effectiveness when implemented. There is a development of a methodology using epistemological features for the categorization of the representations of the gene and its functions in biology textbooks into the five historical models: Mendelian model, Classical model, Biochemical-classical model, Neoclassical model and Modern model. The purpose of this study is to explore which gene models are represented in the two biology textbooks used in lower secondary school in Greece, for 13 to 15-year-old students, that is the basis for understanding more complex genetic concepts in upper grades. Using content analysis, we found that in the biology textbook that is being taught in the 1st Grade, which is about the basic functions of the organisms, the epistemological features of the Mendelian model dominated which could be characterized as aging, while in the textbook that is used in the 2nd and 3rd Grade, which includes fields of environment, metabolism and diseases, inheritance, biotechnology and evolution, the epistemological features of the Biochemical-classical and the Classical model are more often. In both cases, however, the epistemological features of the Modern model are limited. The simultaneous presence of multi/hybrid models is also found in both textbooks, besides, the special epistemological features found are not completely identical to those of the historical models and were used variably in different topics of textbooks. This conceptual diversity in describing the gene concept resulting in lack of conceptual coherence is a potential source of alternative or deterministic conceptions for students. The integration of the Modern model into the biology school textbooks and the indication that the gene concept differentiates according to the historical model used in each topic is strongly suggested.

# Learning to design biology lessons based on socio-scientific inquiry based learning (SSIBL)

*Andri Christodoulou, Ruth Amos, Christina Ottander and Katarina Ottander*

**Keywords:** socio-scientific issues, inquiry-based learning, pre-service teacher education

**Type of presentation:** Oral

In recent times there has been increased interest in how issues surrounding science for and with society are conceptualised, presented and discussed in science classrooms in a way that promotes responsible and active citizenship. One approach to enabling this way of teaching science is through socio-scientific inquiry-based learning (SSIBL). To promote the teaching of science using SSIBL, teachers need to have the appropriate teaching repertoire. Our aim was to explore how secondary science pre-service teachers conceptualise SSIBL through the way in which they operationalize it in their lesson plan designs and classroom materials. Participants included 424 pre-service science teachers in two UK and one Swedish Higher Education Institutions, across three academic years. Data collected include the lesson plans and materials designed to teach science using SSIBL (117 in total). A theory-driven approach was used for the analysis of the lesson designs. Most PSTs planned SSIBL lessons using biology topics, suggesting that biology topics provide particular affordances for developing competence and confidence in teaching using a SSIBL approach, which could then be applied in the teaching of other science disciplines. Our findings also revealed a tension between a willingness to engage students in dialogic learning environments while at the same time designing more structured inquiries for students to engage in. Finally, emphasis was placed on subject matter first, and the use of SSIBL contexts as end-of-unit lessons, rather than as contexts for teaching Biology subject matter. Implications for teacher education are discussed.

# **A frog in a school throat – obstacles in sources of the students scientific knowledge about herpetology.**

*Zofia Chyleńska and Eliza Rybska*

**Keywords:** analysis of contents, textbooks, errors, herpetology

**Type of presentation:** Poster

Textbooks are recognized as one of the most important teaching aids in education, regardless of the subject taught. Often they serve as the main or even the only source of information not only for students but also for teachers. The aim of this study is to analyze the sources of students' scientific knowledge - teachers personal believes and textbooks for primary and junior high schools focusing on their information about amphibians and reptiles, and the communication between teachers, students and textbooks. We are presenting here the possible ideal communication pattern that should occur in a process of construing, writing, correcting and using textbooks in school environment. Authors conducted a qualitative analysis of the content of eleven nature and biology textbooks for the second and third stage of education. Textbooks were analyzed for the presence of surveys and summaries, also authors conducted analysis of content in search for factual errors and appealing graphics – number of them, diversity of presented species and how they are described in text. Furthermore, authors were looking for a core idea in the textbooks, and the teachers attended in in-depth interviews. The interviews were transcribed and analyzed for the presence of substantial mistakes, shaping the attitude of students and teachers' probability of correcting the mistakes from textbooks. The teacher ability to correct those mistakes found in textbooks was also assessed. To achieve that authors focused on communication – we conducted pilot survey concerning teachers advisers and editors of the textbooks. In the result it appear that communication is one sided – teacher does not consult with the authors of the textbook their reflections, and also editors didn't do additional evaluation beside of reviews. In the light of the analysis, none of the books can be regarded as flawless. We have shown that only few from interviewed teachers might put stress on those specific errors and offer students comprehensive lesson about amphibians and reptiles that shape pro environmental attitudes.

# **Analysis of the pedagogical strategies used by prospective teachers to design nature field trips**

*Emilio Costillo, José María Merino, Rocío Esteban, Javier Cubero, José Antonio Regodón and José Ramón Vallejo*

**Keywords:** nature field trips, prospective teacher, pedagogical strategies, teaching and learning activities

**Type of presentation:** Poster

Nature field trips have positive effects on pupils both cognitive and attitudinal aspects. Research has shown that prospective teachers value the importance of nature field trips as a way of enhancing their pupils' motivation and performance, but these activities are often not conducted in a manner that maximizes learning outcomes. In this contribution pedagogical strategies and styles employed in the field by a sample of 206 Primary and Secondary prospective teachers are analysed in relation to students' role as Biology teachers, the role they give to student, the interactions student-teacher and the connection between lectures and nature field trips. Preliminary results show that role of prospective teachers in nature field trips was no active, that there was little interaction students-teacher and that they designed activities unrelated to contents approached at classroom. In addition, there are no significant differences between Primary prospective teachers and Secondary prospective teachers in relation to different studied aspects.

# Cognitive and affective domains in nature field trips designed by prospective teachers

*Emilio Costillo, Isaac Corbacho, Ana Belén Borrachero, María Carmen Conde, José Samuel Sánchez and Vicente Mellado*

**Keywords:** nature field trips, prospective teacher, affective and cognitive domain, Teaching and learning activities, Science Education

**Type of presentation:** Poster

Research shows that nature field trips have a positive effect on pupils in both cognitive and attitudinal aspects. Nevertheless, there are few studies concerning to activities focusing in the cognitive and affective teacher domains, especially in the first step of teacher education. We study the assessment of prospective teachers about affective domain in nature field trips as teaching and learning activities. We analyzed 244 prospective teachers, 147 primary prospective teachers and 97 secondary prospective teachers. We use a single reflection on the merits of the science field trips with respect to the classroom. It was necessary to establish a categorization process. Four possible dimensions were established: affective dimension (motivation, interest, taste for science, ...), cognitive dimension (experiential knowledge, meaningful learning, ...), procedural dimension (scientific method, doing science, management of instruments, ..) and a transversal dimension (respect for living beings, teamwork, improvement of personal relationships,...).

These prospective teachers were very much in agreement with the importance of these activities in enhancing their pupils' affective domain, cognitive domain, transverse competence and procedural knowledge. Most prospective teachers reported that science field trips generated improvements in the cognitive domain. The dimension that less prospective teachers indicated was related to procedural knowledge. There are no important differences between primary prospective teachers and secondary prospective teachers. There are also no important differences regarding the sex of the prospective teachers.

This situation would be in accordance with the bibliography, however, despite the fact that some authors favor its positive aspect on the attitudes of the students, the vast majority of teachers in training in our study consider to a greater extent the advantages that for the student have in the cognitive plane. Currently the affective domain is considered very important in the teaching-learning of Biology because there is a negative view of the sciences. Therefore, it is necessary to work these science field trip in prospective teachers as they play a key role in the teaching and learning of these subjects

# **Biology concepts and Pictorial Fiction Books. Do early years children comprehend?**

*Sue Dale Tunnicliffe and Catherine Brugiere*

**Keywords:** fictional pictorial stories, biology concepts, early years

**Type of presentation:** Poster

Children start learning biology long before they encounter formal educators, the requirements of the curriculum and the knowledge assessed on for school tests. The biology of the area where they live form most first experiences of the biology. The child is part of this biological world and various depictions of it are in many of the early years pictorial fiction books read to them and which they may choose to look at themselves.

Preschool children are young learners meeting with biological topics in their own lives, members themselves in the biological domain, and in biological topics in stories in fictional picture books they are often mythical and objects and problems depicted in anthropomorphic terms. None the less many stories do have a biological basis and present a problem, with which children are familiar and have already noticed at home and their everyday environments. Story telling is an essential human need. It uses narrative, possibility thinking and imagination, and possibility thinking, but do children comprehend the possibilities of the situations depicted in reality and concise the actuality situations presented by these illustrated stories. In this paper we report on one story, *Fish is Fish* (Lionni, L. 1970) of which we firstly identified the biology concepts. Secondly, we wanted to explore whether the listeners understood an anatomical description and related to their existing knowledge ( mental model, Buckley et al. 2007) through drawing their expressed model whose content we analysed by inspection. Lastly, we listened to the class response of 4 year olds as the story was read. We analysed by identifying categories, which emerged through a reiterative reading process, both the out loud spontaneous comments of the listeners and the manner in which the teacher scaffolded the content of the reading for them. Our findings are that whilst children had a basic idea of change as an organism develops, did not spontaneously identify problems such as the transition for obtaining oxygen from water or from air on land, they could literally interpret a description but add other elements from previous knowledge and could relate some of the story events to previous experiences. Our study highlighted the lack of biological knowledge above that of everyday in early years professionals and the opportunities that could be made to discuss basic biology such as and anatomical adaptations to habitat as well as critically identifying problems and solutions.

# Cellular Respiration visualized using Lego; effects of a dynamic analogical model within contexts

*Michiel Dam and Koen Ottenhof*

**Keywords:** Cellular respiration, Situational interest, Lego, Context-based biology, Dynamic analogical model

**Type of presentation:** Poster

Teaching and learning cellular respiration in secondary science education has been found difficult due to its' abstract and complex nature as well as low relevance to students' everyday life. To increase relevance, concepts can be taught within contexts. Abstract and complex processes on the molecular level such as cellular respiration, however, are hard to visualize and require a model that covers adequate representation. In this study we focused on such visualization by using a dynamic analogical model (Lego® visualization) within contexts for the topic of cellular respiration and studying the effects on student conceptual learning and student situational interest in the materials. Results show significant increase in situational interest in the materials using the dynamic model without decrease in student learning or relevance. Specific advantages and disadvantages of using a dynamic analogical model for teaching cellular respiration in contexts are presented.

# Effects on primary and comprehensive school teachers' attitudes, knowledge, and self-efficacy of health education during their participation in an activity program in class

*Sarah Dannemann*

**Keywords:** Health literacy, Teacher professionalism, Concept of school health education

**Type of presentation:** Poster

The WHO (2017) recommends 60 minutes of moderate physical activity a day – but children and young people are not active enough. The KIGGS study, a longitudinal large-scale survey, showed that 50 % of German primary school children have enough physical activity but only 10 % of the adolescents reach this goal (RKI 2014). Young people from deprived backgrounds are more frequently affected (Hurrelmann et al. 2006). School is considered one setting that allows to face social inequalities and initiate reconstructions in students' attitudes, knowledge, and health behavior. However, research shows the difficulty of affecting health-related behavior (Schwarzer 2007).

To develop and to evaluate a conception for an activity program that can be integrated in daily school practice, two institutions in Hannover cooperated doing a two-year comparison study at five German schools. The first partner is the cluster of excellence Rebirth located at the Hannover Medical School. The second partner is the Institute of Biology Education. The cooperation addresses both, medical research and educational requirements. Activity phases are integrated into the lessons which makes the activities only two to three minutes long and easy to conduct.

The main goals of this study are to analyze:

- effects on students' individual health parameter, esp. on the length of their telomeres,
- effects on teachers' attitudes, knowledge, and self-efficacy during their participation in the program,
- effects on school development according to the implementation of the program.

First results of interviews with primary (n=12) and comprehensive school (n=15) teachers are presented. While most of the primary school teachers implement physical activities in nearly all lessons, just three of the comprehensive school teachers perform activities. Only seven teachers at all stated that they learned about the importance of physical activity in university teacher education – most of them (n=12) learned about this concept during their own teaching practice. Due to their experience, many primary school teachers thought positively about their self-efficacy to perform the activity program, while the comprehensive teachers asked for external help from sports scientists. Yet, all teachers stressed the importance of an activity program for students. Many of them hoped for positive impact on their own health.

# **Discipline-based or context-based? A comparison of Biology curriculum in four countries.**

*Edith Dempster*

**Keywords:** Biology curriculum, vertical progression, discipline-based approach, context-based approach

**Type of presentation:** Oral

Approaches to school biology curriculum are divided between those who advocate a discipline-based approach, and those who advocate a context-based approach, drawing on students' everyday experiences. The claimed advantage of a discipline-based approach is that biology is organized vertically, progressing from knowledge of independent facts through progressively more inclusive concepts to a single unifying principle. Mastering a vertically-structured subject is claimed to promote social justice and equity.

Arguments in favour of a context-based approach are largely to do with student motivation. Beginning with the everyday, students can see the relevance of what they are learning. This study investigated the breadth and depth of four secondary school biology curricula, searching for evidence of vertical progression, and classifying each as discipline-based or context-based. The curricula selected were South Africa, Kenya, Singapore and British Columbia. Content analysis was used to establish the breadth of each curriculum. A level of depth was assigned to each subtopic, on a scale of 1-4, with 1 having least depth, and 4 greatest depth.

Findings were that all four curricula had a strong discipline focus, with little reference to the everyday. Vertical progression could be identified in three of the four curricula, Kenya being the exception. Progression was strongest in Molecular & Cellular Biology, Genetics & Heredity, and Evolution & Diversity. It was less evident in Ecology and Life Processes in Animals and Plants.

Although all four curricula began with a set of stated aims, the content to be taught was discipline-based and structured vertically, with the exception of Kenya. Some alarming tendencies were evident, such as neglect of the Plant sciences and Ecology.

# Gender Differences in attitudes towards animals and nature

*Inga Desch, Christian Vollmer and Peter Wüst-Ackermann*

**Keywords:** Gender, empathy towards nature, empathy towards animals, connectedness to nature

**Type of presentation:** Poster

In several studies gender differences in empathy and ecological behavior were found. Women are expected to have a higher empathy towards animals. The findings for environmental behaviour are contradictory. In our study we want to find out whether the sex or the self-reported expression of gender on a 7-point Likert scale is more predictive for empathy and connectedness to nature. Therefore over 200 students will be asked from October 2017 to February 2018. We use four measurements: the connectedness to nature scale (CNS; Mayer & Frantz, 2004), the composite respect for animals scale (CRAS-S; Randler, Binngießer & Vollmer, 2017), the inclusion with nature (INS; Schultz, 2002) and the dispositional empathy with nature (DEN; Tam 2013).

# Engaging students in studying Human biology through Digital Storytelling

*Maria Dokopoulou and Evangelia Pavlatou*

**Keywords:** Digital storytelling, Human Anatomy, Physiology

**Type of presentation:** Oral

Our study focuses on exploring students' engagement in Human Biology using the construction of several digital stories (Digital Storytelling) in Human Anatomy and Physiology as a field of the Biology curriculum in Greek upper secondary education system. 15 year old students used software to make digital stories about Human organ systems and relevant health problems that were addressed by exploring possible causes and solutions. To gain an understanding of student engagement, personal interviews were conducted. Students' responses were coded under the three dimensions of students' engagement: behavioral, emotional and cognitive engagement. Our findings indicate the impact of Digital Storytelling in students' engagement in the Biology content and the learning procedure. Both positive and negative perspectives are discussed to critically evaluate the strength and the weaknesses of implementing such an initiative in Biology teaching.

# **Using problematized contexts to introduce the idea of classification criteria in taxonomy. Context-transference and resistant ideas.**

*Jordi Domènech Casal*

**Keywords:** taxonomy, classification, context, transference, scientific skills

**Type of presentation:** Poster

Students present difficulties to classify organisms and understand taxonomic classification criteria. Using different contexts has been proposed as a way to overcome such difficulties. We have developed a taxonomy learning sequence to teach classification abilities (choosing classification criteria, constructing a classification tree, classifying an item) in several contexts and tested student's abilities to transfer it to living beings classification. Students' difficulties to transfer classification abilities from different contexts are described. Resistant ideas on classification emerge and distort students' classification abilities when applying it to living beings contexts.

# **Environmental education from the Biology class. Animal abuse as a fully encompassing content**

*Jenny Duarte, Edgar Valbuena and Maria Cristina Pansera de Araujo*

**Keywords:** Teaching of biology, School environmental education, Didactic content knowledge, animal abuse

**Type of presentation:** Poster

In Colombia, a role of the biology teacher is the teaching of Environmental Education (EA), what happens because environmental school projects are usually assigned to Biology teachers, who teach the EA from their classes, linking the contents of biology. This paper analyzes the practice of a teacher, teaching EA in the biology class, from the problem of animal abuse. Carrying out its analysis within the framework of the Didactic Content Knowledge (CDC), emphasizing the categories related to content and teaching purposes. The objective focuses on characterizing and analyzing how from the Biology class the teacher approaches the teaching of EA.

The methodology of the research is approached from an interpretative approach, analyzing the action represented in the videotapes of the teacher's classes. For the systematization of these classes, the content analysis was implemented, selecting episodes related to the two categories of analysis, later interpretation proposals were elaborated and finally relationships were established between the contents of the EA and school biological contents. As results, we find that the teacher performs a didactic sequence throughout different classes, in which she proposes strategies and uses didactic resources, which allow students to establish which animals are mistreated by the human being, the characteristics of animal abuse and the ways to avoid it, propitiating simultaneously the construction of knowledge around various school biological contents.

With this analysis, we identified that, for the teacher, environmental education is circumscribed in the biology curriculum, making conceptual biological contents more complex with bioethical and socio-environmental aspects. In addition, we infer that their pedagogical practice could correspond to the current trend called curricular environmentalization as a reflexive and action process aimed at integrating EA into the curriculum. We conclude that in the teaching of Biology we can promote a perspective of curricular integrality, evident in the case of Isabella who manages to establish socio-environmental curricular integrations from situations related to life and living things.

# The Levels of Biological Organisation – Engaging with Students’ Conceptions and Promoting a Coherent Understanding Using the Example of the Carbon Cycle

*Katharina Düsing, Roman Asshoff and Marcus Hammann*

**Keywords:** students’ conceptions, levels of biological organisation, carbon cycle, tracing carbon atoms

**Type of presentation:** Poster

This study investigates students’ conceptions of the carbon cycle with regard to the problems of coherence students have when explaining the carbon cycle, how current school textbooks and teaching methods engage with the problems of coherence, and whether – and if so to what extent – using the targeted instructional strategy of tracing carbon atoms across the levels of biological organisation helps students to gain a coherent understanding of the carbon cycle. In an explorative study, a total of 130 students completed the diagnostic task, and an additional 12 students completed both the diagnostic task and were interviewed. The primary results show that the students identified few components of the carbon cycle, tended to trace carbon atoms exclusively at the level of the organism, and had difficulties identifying organic carbon compounds, especially during processes in which carbon compounds are transformed. The textbook analysis leads to the assumption that the information provided in most school textbooks alone is not sufficient for students to gain a coherent understanding of the carbon cycle in the sense of making them environmentally literate. As next step, we will conduct teacher interviews as part of the second research question. Afterwards, we will test the instructional strategy of tracing carbon atoms across the levels of biological organisation.

# **Collaborative care for animals in class – Effects on the students’ relatedness and their flow experience in biology lessons**

*Alexander Eckes, Nadine Großmann, Annette Textor and Matthias Wilde*

**Keywords:** Self-Determination Theory, Relatedness, Flow, Primärerfahrungen, Living animals

**Type of presentation:** Oral

Relatedness is one of the basic psychological needs anchored in Self-Determination Theory. This need can be satisfied by meaningful interactions and positive emotions. One way to foster positive emotions in biology lessons is working with living animals. Furthermore, taking care of the animals together with the teacher might enable meaningful interactions between the teacher and the students. In consequence, students’ perceptions of relatedness may be influenced positively. Students’ relatedness as well as positive emotions play an important role for their motivation in class. Applying living animals in the classroom might therefore also foster their flow-experience as a positive quality of motivation in biology lessons. This study investigated the effect of collaborative animal care in biology lessons on students’ feelings of relatedness towards their teacher trainees as well as students flow-experience using a post-test design. 613 fifth and sixth graders ( $M_{age}=10.68\pm 0.67$  years) participated. This study is composed of one experimental and two control groups. The experimental group ‘care’ included prior care for animals (*Micromys minutus*) for four weeks and afterwards lessons with living animals. The students of the first control group ‘mice’ only had lessons with living animals, but no prior animal care. The second control group ‘laptop’ worked with video clips of the animals using laptops. To examine the effects of caretaking, we used an adapted version of the scale ‘relatedness’ of the Intrinsic Motivation Inventory (Ryan, 1982). Results for the students’ relatedness provided a significant main effect and showed significant Games Howell post-hocs between the three treatment groups. Students of the ‘laptop’ treatment had the lowest relatedness. Students of the ‘care’ treatment had the highest relatedness. We assessed students’ flow-experience in two lessons using the Flow Short Scale (FSS; Rheinberg et al., 2003). Analysis showed significant main effects in both lessons. In both lessons, working with living animals led to a significantly higher perception of flow than did working with laptops. Taking care for the animals prior to the lessons did not influence the perceptions of flow positively beyond the mice treatment for both measurements. Working with mice in biology lessons as well as collaborative animal care prior to the intervention had a positive impact on students’ relatedness with the treatment ‘care’ resulting in the highest gains. Working with mice also impacted students’ flow-experience positively. Collaborative animal care showed no additional benefit.

# Exploring the role of person analogy in young children's reasoning about the biological world

*Marida Ergazaki, Aggeliki Dimitrakopoulou and Spai Alexandra*

**Keywords:** personifying reasoning, person analogy, naïve biology, early year biology education

**Type of presentation:** Oral

Young children have a 'naïve biological theory', the core of which includes certain predictive/explanatory reasoning devices. One of these allows children to predict the properties/behaviors of biological entities about which they don't know much, by drawing upon their knowledge about humans. This kind of reasoning is known as 'person analogy' or 'personifying reasoning' (PR). Most of the literature on PR sets focus on young children's predictions about the properties/behaviors of the target-entities to ascertain whether these are similar to the ones about humans. Nevertheless, what seems to be really important in order to trace PR is to shed light on how children justify their predictions. This was actually taken into account by Inagaki & Hatano (1991). Exploring the use of PR in a more meaningful way, they came to the conclusion that this reasoning device is used by young children frequently and, more interestingly, in a controlled manner. Since these conclusions are potentially important for early biology education, it seems purposeful to explore whether they could be crosschecked in a western cultural context nowadays. Thus, our study addresses the questions of (a) whether young children actually use 'personifying reasoning' to predict the properties/behaviors of target-entities that are less familiar to them than humans, and (b) whether they actually use it in a controlled manner or not. Our informants were 241 conveniently selected preschoolers (121 girls/120 boys, age 4-6), attending public kindergartens in several areas of Patras. Tracing their reasoning was performed through individual, semi-structured 15-20 minute-interviews. The interview protocol was that of Inagaki & Hatano (1991). It consisted of open-ended questions requiring predictions/justifications about a person and a living target-entity. Half children were asked about a person and a grasshopper, while the other half about a person and a tulip. Every child was asked six questions (Qs) of three different types: 'Qs of similar reaction', 'Qs of dissimilar reaction / PR implausible', 'Qs of dissimilar reaction / PR plausible'. The tape-recorded interviews were transcribed and coded with 'NVivo'. We coded children's responses regarding (a) the type of the reasoning, and (b) the soundness of its conclusion about how the target-entity would react in each situation. Some of our findings are in line with Inagaki & Hatano (1991), while others are not. So, PR does not necessarily seem to be our informants' preferable tool when it can lead them to right conclusions, whereas it seems to be so when it cannot.

# **‘How are plants dispersed?’ Children’s Intuitive ideas in 6th grade**

*Bernat Esquiús Monrós and Arnau Amat Vinyoles*

**Keywords:** Plant biology, Plant life cycle, Children’s intuitive ideas, Misconceptions

**Type of presentation:** Poster

This study aims to describe and to understand how 6th grade students explain the dispersion of plants. The main goals were to identify students’ intuitive ideas and analyze how students’ ideas were modified. Even though, to the authors knowledge, few research were available that discuss the issue of dispersion in elementary students, it is well know that study plants cycle is often a difficult topic that usually has been neglected in the school. Data was obtained interviewing 12 students in different moments of the lesson plan that was conducted. The results show that students are able to identify the main dispersion factors, such as wind and animals. However, students have more difficulties to describe what part of the plant can travel from one place to another and have the power to germinate. From our point of view, students improved their conceptions throughout the lesson plan even though some misconceptions remained in their explanations.

# **Microbiology learning through homemade microorganisms' culture: role of students' emotions and values**

Rocío Esteban Gallego, José María Marcos-Merino and Jesús Gómez Ochoa de Alda

**Keywords:** Microbiology, Practical activities, Emotions, Motivation, Teachers training

**Type of presentation:** Oral

Microbiology teaching faces the difficulty of approaching living beings not observable by the human eye and usually related to different kinds of diseases. As a result, core microbiological concepts are related to loads of misconceptions. Due to research has pointed out that teachers' misconceptions are one of the main origins of students' misconceptions, it is necessary to develop effective teaching-learning sequences of Microbiology and address these interventions in Biology Education courses of future teachers' training. Raised educational interventions must be motivating, since research has shown that positive emotions experienced by students promote learning processes whereas negative ones limit them. Some ways to encourage motivation are to highlight effective applicability of taught contents and using practical approaches. In this contribution is described a practice intervention carried out with 139 pre-service Primary teachers (University of Extremadura) in which basic microbiological concepts (such as microorganisms' ubiquity and diversity and asepsis and sterilization methods) are approached through microorganisms' culture. Moreover, it is discussed how to prepare a microorganisms' culture medium in a homemade way to be able to perform this activity in a Primary classroom. Results show that designed intervention is effective regarding Microbiology learning and that learning outcomes are significantly correlated to students' emotions and values: students who got a better mark in Microbiology test are those that experienced more positive emotions (trust, satisfaction, fun, pride, gratitude and awe) and value better this practice for their future as Primary teachers ( $p$ -value $<0.05$ , Spearman correlation). These results reinforce the need to implement this kind of motivating interventions in order to improve prospective Primary teachers' qualification and their future teaching action.

# Frequency of mathematical exercises in biology classes

*Martin Feike and Carolin Retzlaff-Fürst*

**Keywords:** biology classes, mathematics, scientific literacy

**Type of presentation:** Poster

Biology classes make the claim to improve scientific literacy of the students by using scientific methods in a similar way as used by biologist in their scientific work (McComas 2015). This would implicate the quantification of data, the mathematical presentation of data and the usage of mathematical tools for the investigation of causal relationships. Although selected mathematical skills of pupils within biology lessons (e.g. creating and interpreting of diagrams, learning with mathematical models) were in the focus of didactic research (Upmeier zu Belzen & Krüger 2010), no information is available about the extent of usage of mathematical tools within recent biology classes. In this study exercises of German schoolbooks for biology classes were used as a first indicator for the application of mathematics inside the biology lessons at school. The observed low proportion of 2–3 % of exercises requiring mathematical skills of the students in schoolbooks for biology till the 10th grade shows that probably mathematical tools are rarely used in biology classes. These findings are in contrast to the considerable role of mathematic tools for the process of making findings in the scientific biology.

# Measurement Tools for the Competence Model for Environmental Education

*Lisa Felix-Strishock, Bruce Johnson and Sanlyn Buxer*

**Keywords:** environmental behaviors, environmental knowledge, measurement

**Type of presentation:** Oral

The Competence Model for Environmental Education (Kaiser, Roczen & Bogner, 2008) shows promise as a framework for environmental education program development in multiple ways: 1) it addresses and maintains findings from previous environmental behavior research; 2) is specifically intended to be used in developing these programs, and 3) can be statistically tested. This model is currently undergoing revisions and testing in Germany and the United States. This study focuses on the efforts in the United States to develop two valid and reliable measurement tools for use with elementary aged students in the U.S., the Expanded Ecological Concepts Questionnaire (ECQ) and the Revised General Environmental Behaviors (GEB) scale. Year One of the study used Exploratory Factor Analysis, Confirmatory Factor Analysis and Classical Test Theory analysis techniques to explore the quality of the instruments. Results indicated high reliability and validity for the GEB scale, while ECQ results suggested the need for further testing and model modification. Following instrument refinement, Year Two analysis applied the same techniques along with Rasch analysis. Results once again revealed high levels of reliability and validity for the GEB, while testing on the ECQ similarly produced positive results with the suggestion of minor item modification.

# Promotion of emotional competence in inclusive human biology lessons in class 5/6

*Laura Ferreira Gonzalez, Igor Osipov, Dennis Hövel, Thomas Hennemann and Kirsten Schlüter*

**Keywords:** Inclusion, Health education, social and emotional competence

**Type of presentation:** Oral

In 2008, the UN Convention on the rights of persons with disabilities was ratified. Thus, schools are presented with the task to promote both subject-related learning and the personal development of the pupils during lessons at the same time. Personal development includes, among other things, to acquire social and emotional competence. Training these abilities is considered a key aspect of successful inclusion processes (Reicher, 2010). The research project presented here uses human biology content for the targeted promotion of emotional competence (Pons, 2004) of class 5/6 pupils. It is examined whether targeted promotion of emotional competence is possible by an intervention during biology lessons, which take place twice per week. The study is based on a quasi-experimental design. The intervention group (IG) (of 295 pupils, mean = 11.4 years, SD = 0.76) participated in a 24-hour treatment. The treatment links the content of human biology lessons with aspects of emotional competence. The control group (CG) (of 250 pupils, mean = 11.4 years, SD = 0.78) participated in regular human biology lessons in parallel. The development of emotional competence was gathered with the Emotional Competence Questionnaire (ECQ, Emotionaler Kompetenzfragebogen; Rindermann, 2009) in the pre-post test design. Confirmatory factor analysis (CFA) was used to test the factor structure of the questionnaire. Differences in treatment effects between intervention and control group were examined on the basis of latent mean differences between the two time points of measurement with the help of the latent difference score model. The observed effect sizes for the intervention period (T1 - > T2) are in favour of the intervention group. The effect sizes are in between  $d = 0.17$  and  $d = 0.31$  and affect the scales Recognizing and understanding own emotions, Recognizing emotions in others, Regulation of the emotions of others and Attitude to emotions. The results indicate that the emotional competence of pupils can successfully be promoted within the scope of biology lessons.

# Dialogue and Linguistic scaffolds as tools to help students making investigable questions

*Concepció Ferrés Gurt and Jordi Domènech Casal*

**Keywords:** investigable questions, scientific thinking skills, scientific competence, inquiry

**Type of presentation:** Oral

Inquiry-Based Science Education has been proposed as a methodologic strategy to deepen in the comprehension of scientific models, scientific argumentation and the nature of science. When asked to design inquiry projects, students usually propose “information questions” that are not investigable nor connected to an effective research work. Some authors suggest that these difficulties can be overcome and assessed with appropriate scaffolding. We have developed and applied two scaffolding strategies (guided dialogue and linguistic scaffolding) with 97 students. Students’ abilities to pose investigable questions and design experiments are assessed with a 5-levels rubric. We discuss main students’ difficulties and propose ideas to improve student’s inquiry abilities.

# **Giving the silent a voice: How rangatahi used Actor-Network Theory to unravel the complexity of a New Zealand native forest ecosystem.**

*Bev France and Sally Birdsall*

**Keywords:** Actor-Network Theory, Traditional Ecological Knowledge, Socioscientific Issues, Ecosystem relationships

**Type of presentation:** Oral

In New Zealand, the poison sodium fluoroacetate (1080) is used to control pest animals that attack native birds and cause damage to native forests. This socioscientific issue is of particular concern to Maori as they enact their role as guardians of the environment (kaitiakitanga). A Māori world view is expressed as them being within an ecological relationship rather than separate from an ecosystem. This interconnectedness of nature and humans is central to Traditional Ecological Knowledge where values and beliefs are an important part of the knowledge system. This research has identified and developed Actor-Network Theory to identify the participants (actants) involved in a native forest ecosystem disruption when 1080 is applied to control predator pests. Twenty-eight rangatahi (young Māori) and their kinspeople (iwi) produced posters (Cartography of Controversy) to identify the actants, their emotions and connections in order to reveal this complex biological interaction. It was shown that it was possible for these rangatahi and their iwi to record both the biological concepts and the emotions and values of all actants that increased their perception of the variety of viewpoints and components that needed consideration when critiquing this strategy. This strategy and analysis has resonance for other ethnic groups to explore this way of linking TEK with biological understandings of the ecosystem.

# Acquisition of Mental Models in the Mathematical Modelling of Population Dynamics

*Dagmar Frick and Claudia Nerdel*

**Keywords:** mathematical modelling, population dynamics, mental models, representations

**Type of presentation:** Poster

For an active work with mathematical models in biology, like models of population dynamics, the mathematical modelling cycle (Blum & Leiß, 2005) can be used. The aim of this modelling cycle is the deduction of a concrete model from a real problem situation by translating between the real world and mathematics in both directions. Within this modelling cycle, internal and external representations can be distinguished. The situation model is the internal representation and corresponds to the mental model an individual has of the real problem situation. External representations within the modelling cycle can be realistic or logical images. Different forms of external representations can lead to different mental models in the processing of tasks (see "structure mapping effect" (Gentner & Markman, 1997)). In addition, the expertise has an influence on the nature and the extent of mental models since the domain-specific knowledge is used to solve tasks and problems (Rothe & Schindler, 1996). Against this background, it is to be investigated whether different types of abstract image and the expertise of a learner have any influence on the quality of mental models for population dynamics. To investigate this question, a multivariate design is used. As independent variables, the expertise of the participants (biology vs. mathematics students), as well as the degree of abstraction of the external representation (realistic vs. logical images), are varied. According to Mayer (2009), the acquisition of mental models as a dependent variable can take place by means of reproduction and transfer questions. Within the scope of the study, the participants (N=12) work on four tasks with different population dynamics contexts, whereby the factual knowledge and the general understanding of the biological processes are recorded by using the method of 'thinking aloud' (Konrad, 2010). The statements collected during the problem-solving process can be used to draw conclusions about the mental models of the participants and to determine how elaborate the learner's mental model is.

# Is biodiversity necessary in the ecosystem? A classroom experience

*M<sup>a</sup>-Jesús Fuentes-Silveira, Juan Rivadulla-López, Susana García-Barros and Cristina Martínez-Losada*

**Keywords:** Biodiversity, Ecosystem, Compulsory Secondary School, Teaching

**Type of presentation:** Poster

The consequences of species becoming extinct may lead to deteriorating diversity, functional disintegration and the transformation of the ecosystem. Although no direct nor total correlation between biodiversity and stability can be established, a greater richness of species does increase the ecosystems temporary ability to withstand and handle changes.

On the other hand, school science is characterised by paying a great deal of attention to the descriptive and explanatory framework of reality. Concerning biodiversity, the key idea of the descriptive sphere needs to be taken into consideration - the most diverse ecosystems tend to show a greater capacity to react before changes – and to the explanatory one – this capacity can be put down mainly to the fact that a larger trophic exchange occurs.

The purpose of this paper is to design and assess an activity related to the role and function of biodiversity in ecosystems for 4th-year Spanish Compulsory Secondary School pupils (16 years).

In order to design the activity, the key ideas are used for reference purposes, and the aim is to analyse two ecosystems showing different degrees of diversity highlighting the trophic relationships. The activity raises different topics where the pupils need to reflect on the changes happening when a population disappears. In this particular paper there is only room to deal with the specific question being researched, which is answered by 21 pupils at the beginning of the activity, and, then, once again at the end of it, as a sort of self-assessment.

A month later they perform an application activity, which is subsequently undertaken again one year later by 18 of the initial participants.

In order to carry out the analysis of the pupils' answers linked to the key idea of the explanatory sphere, different categories were established depending on their degree of greater or lesser accuracy at different times during the research process. Degrees of adequacy were likewise established so as to gain insight into how well the key idea was acquired and assimilated by the pupils concerned.

The findings show that the pupils' knowledge about the importance of diversity to ensure stability in an ecosystem vis-à-vis commotion does improve and is actually upheld over time. During the activity and one month later, most pupils recognise this fact and a considerable number of them even specify the trophic relationships as a stability factor. However, after one year, no reference to such relationships are made.

# Ideas about the model of what a living is being expressed by secondary school pupils and teachers in training

*Susana García-Barros, María Jesús Fuentes-Silveira and Paula Ramos-Fariña*

**Keywords:** Model of living being, Secondary education, Teachers in training, Conceptions

**Type of presentation:** Poster

The goal of this study is to find out what ideas first and last-year Secondary School pupils (12 and 16 years old respectively), as well as a group of generalist Primary School teachers in training (not specialised science teachers) express about the concept of living being. Their ideas are expressed individually by 71 first-year pupils, 36 fourth-year pupils and, finally, by 45 groups of 3-4 people as far as the teachers in training are concerned. In all cases, the responses are collected during educational activities specifically aimed at constructing a model of what a living being is, as regards the Secondary School pupils, and at conducting a conceptual analysis – a model of what a living being is – for the teachers in training. The Secondary School participants are asked to reflect on this topic while answering specific questions and subsequently need to develop their own definition of a living being. The teachers in training also elaborate a definition of a living being, yet given their higher degree of maturity, they are previously asked to reply to some questions of a more open-ended nature. More specifically, the questions try to activate basic aspects of the model consisting in: identifying the biological diversity; the functional unit (nutrition, reproduction, relationship); the cell composition and the idea of evolution/adaptation. The answers were analysed using these different aspects and, specifically, different levels of exactness were established in order to analyse the definitions provided depending on their scope and accuracy.

The results show that the future teachers have a wider perception of biological diversity than the Secondary School pupils. On the other hand, the latter, and especially the older ones, are able to point out features common to living beings more accurately than the university students answering an open-ended question.

Constructing a definition of living being holds difficulties for the youngest pupils. Their definitions are rather incomplete despite having reflected on the features of living beings before producing their definitions. It holds problems for the university students as well in spite of their maturity, because the more accurate definitions characterising the living beings in terms of their functions, cell composition and adaptation/evolution are less frequent than expected.

# Learning in a science outreach laboratory: Development of a learning material on the ecology of the rhizosphere

*Rita Gazdag, Martin Willmann, Jörg Großschedl and Marcel Bucher*

**Keywords:** science outreach, preconception, inquiry-based learning, misconception, experimenting, design-based, Research model of educational reconstruction

**Type of presentation:** Poster

A science outreach project on plant-microbe interactions, supported by the Cluster of Excellence for Plant Sciences (CEPLAS) and the Robert Bosch Foundation is being conducted at the Institute for Biology Education and the Botanical Institute (University of Cologne). One novel topic of this science project is the ecological-evolutionary genetics of mycorrhizal fungi and nitrogen-fixing bacteria as part of a vital microbe community in the plant root. We aim to transfer it from a state-of-the-art plant molecular laboratory to the high school level. Students experiment in our laboratories with the aid of our evolving learning material. The latter is based on the students' conceptions and research findings on their inquiry-based learning.

For this process, we applied two research methodologies. On the one side, we use the model of educational reconstruction to devise the learning material by drawing on the subject matter analysis with geneticists of the plant root and on the students' conceptions based on interviews before and after each lab experiment week. On the other side, we planned several cycles of lab experiment weeks that are successively optimised based on the students' conceptions and the methods necessary to eradicate their difficulties with doing experiments. It also entails the consideration of three different biological disciplines (ecology, evolution, and genetics) regarding the rhizosphere. Altogether, these three major design principles make up a design-based research approach, the second methodology: 1. the consideration of students' conceptions, 2. the implementation of instructional strategies fostering scientific inquiry, and 3. multiperspectivity of three disciplines in biology.

We are the first to elucidate students' conceptions about plant root-microbe interaction, mycorrhiza and nodulation symbioses, for which we included photo recognition before the lab experiment week. Afterwards, we conducted the identical semi-structured interviews and concept mapping. The comparison showed significant changes in students' understanding of central aspects of the evolution, occurrence, and genetic mechanisms underlying both forms of symbiosis indicating the learning efficacy of the materials. For example, students realised that phenotypic variation due to plant-microbe interactions was dependent on soil environmental factors. These findings guide the further enhancement of the learning material. In 2018 two similar cycles including video assessments will be conducted to follow students' learning material use. Finally, we will evaluate the successive combination of these three design principles with respect to the learning process of students and the development of the learning material.

# Is teaching Biology through socioscientific issues enough for the development of argumentation skills?

*Martha Georgiou, Evangelia Mavrikaki and Constantinos Constantinou*

**Keywords:** argumentation, socioscientific issues, SSI, Biology, Biotechnology, scientific literacy

**Type of presentation:** Oral

During the last decades research on the development of students' argumentation skills is growing, as argumentation is considered to play central role in the effective teaching of Science. It is suggested that students should be given opportunities to express arguments and teaching Science through socioscientific issues (SSIs) can create such opportunities in classroom, as SSIs are controversial issues with several implications. Moreover, content knowledge and conceptual understanding are initial components of argumentation skills. The purpose of our research was to identify to what extent teaching Biology only through SSIs for a long period of time contributes to the development of students' argumentation skills even when they lack the cognitive background about the subject they are asked to argue. We worked on a random sample of 20 Cypriot students who were asked to write their opinions on various SSIs on Biotechnology using open ended questions. These students had previously been taught Biology only through SSIs for two years, but they had never been taught anything about Biotechnology. Their answers were collected and assessed by Toulmin's Argumentation Pattern combined with Dawson and Venville's level scale. Results revealed that students could not formulate high level arguments. However, in many answers students expressed the need to be provided with more information about the negotiating issue and/or an expert's opinion in order to finalize their own point of view and make a decision. Therefore, it was obvious that although the lack of knowledge limited students to low level arguments they stood critical on how they should work when lacking the relevant knowledge. This kind of students' consciousness is a step closer to scientific literacy. Hence, we believe that both an appropriate teaching framework and the cognitive background would better enhance argumentation skills, which are considered to be necessary to future scientifically literate citizens. Further research should be conducted on this direction.

# Epigenetic literacy and the implementation of epigenetics in school biology

*Niklas Gericke, Birgitta McEwen and Karin Thörne*

**Keywords:** Biology curriculum, Delphi study, Design study, Epigenetics, Teaching strategies

**Type of presentation:** Oral

In this study we aim to define what epigenetic literacy should be, and further investigate how it can be implemented in school biology. Epigenetics is the understanding of how the environment interplays with genes, and thus how the environment can affect human characteristics and behaviour. ‘Epi’ derives from the Greek word for ‘over’ and ‘above’ and the word ‘epigenetics’ refers to the mechanisms acting ‘above’ the sequence of the DNA base-pairs. Epigenetics has revolutionized biological theory since it explains how our life style, including factors such as exercise, stress and nutrition, influences our genes. Hence, everyday lifestyle decisions can materialistically explain cell changes and give information about the future health of, for example, students. Health issues are highly profiled in media and society today. However, epigenetics is not yet included in the biology curricula in Sweden or many other countries. Therefore, this study aims to identify what should be taught in school biology about epigenetics, and investigate how it can be integrated in genetics education.

The study includes two ongoing sub-studies: a Delphi study and a Design study we investigate what epigenetic processes and conceptions a citizen needs to know to be able to make relevant decisions concerning both personal and social issues related to epigenetics. In the design study we develop, implement and evaluate a teaching module based on the findings from the Delphi study. Twelve in-service biology teachers at lower and upper secondary schools will take part in this study.

In the Delphi study we identified three main areas of epigenetic literacy regarding 1) Epigenetic content knowledge, including core ideas of mechanisms, chromatin, cell differentiation, cell memory, enzymatic control, life history, reversibility and risk; 2) Epigenetic and society, including core ideas of epigenetics related to its influence on lifestyle, diseases, pregnancy, ethics, manipulation of organisms, policy, forensics, policy and crimes; 3) Organization of teaching epigenetics, an area in which most experts recommend that epigenetics should mainly be integrated with the genetic units, but also with other biology topics such as evolution, ecology and health education.

The Delphi study show that epigenetics is considered a controversial topic from a scientific perspective because the view of epigenetics as a paradigm shift or not differs among the experts. Therefore, many experts recommended that epigenetics should be taught from a nature of science perspective. At the ERIDOB conference results relating to the design study will also be presented.

# Recording and Promotion of subject-specific Professional Knowledge and Beliefs of prospective Biology Teachers

*Katharina Gimbel and Kathrin Ziepprecht*

**Keywords:** Professional Knowledge and Beliefs, Biology teachers, interlinked learning environment, Genetics

**Type of presentation:** Oral

Professional competence of biology teachers consists of content knowledge (CK), pedagogical content knowledge (PCK), beliefs about nature of science (NOS) and beliefs about learning content and instructional practice (BALI). These forms of knowledge and belief can be concretised by subject and subject content, e.g. for the subject biology and its content genetics. There are correlations between particular aspects of professional competence which have been extensively studied. In biology, for instance, CK and PCK are associated in a middle-range positive correlation (Großschedl et al. 2015). In mathematics these knowledge forms present a positive correlation with constructive BALI (Krauss et al., 2008). The latter shows a highly negative correlation with transmissive BALI (Voss et al. 2011).

Currently, various possibilities, such as interlinking forms of knowledge in a learning environment, are being discussed and tested to foster professional competence. This study pursues to gather relevant subject-specific and content-specific forms of knowledge and belief to determine the effectiveness of an interlinked genetics learning environment. It is a component of the project PRONET, part of the „Qualitätsoffensive Lehrerbildung“, which is a joint initiative of the Federal Government and the Länder and aims to improve the quality of teacher training. It is funded by the Federal Ministry of Education and Research. The research questions are: (Q1) Which correlations do subject-specific and content-specific beliefs show? (Q2) What correlations exist between CK, PCK and these beliefs? (Q3) How much does a subject and pedagogical interlinked learning arrangement influence CK, PCK and beliefs? To answer Q1, university students participating in the main study (N=106) completed a questionnaire focused on biology and genetics regarding to NOS as well as constructive and transmissive BALI. Additionally, subsample data (n=14) concerning CK and PCK for genetics is included (Q2). To answer Q3, a subject and pedagogical interlinked learning environment relating genetics was developed in a within-subject design. Data was collected and evaluated at three measurement points. Results show e.g. that correlations between analogue belief systems on subject and content levels, e.g. between constructive BALI for biology and genetics, present a consistent belief system among the university students. An approach with interlinked subject and pedagogical contents shows a significant higher increase of pedagogical knowledge than a non-interlinked approach.

# **Study of sexually transmissible diseases in commercial films: contributions to health education in teaching training**

*Eliane Gonçalves Dos Santos and Maria Cristina Pansera de Araújo*

**Keywords:** Teacher training, Health, Movies in education

**Type of presentation:** Poster

Health Education (ES) is discussed in schools and universities in a reductionist perspective, aiming at more to cure. In the last decades, Sexually Transmitted Diseases (STDs) and Acquired Immunodeficiency Syndrome (AIDS) have seen a significant increase in the Brazilian population, due to the lack of information and adherence to safe sex practices. In this context, it is necessary to promote the discussion with teachers in initial and continued formation on the incidence of sexually transmitted diseases in Brazilian young and old. The paper discusses a didactic proposal with commercial films in order to elicit the understandings of a group of teachers in training on STDs.

# Students' views on the value of protecting biodiversity

*Marcus Grace, Carys Hughes and Janice Griffiths*

**Keywords:** biodiversity, ecology, values, social context

**Type of presentation:** Oral

The modern science curriculum calls for students to recognise the connections between science and values. In relation to biodiversity conservation, the results of this research strongly suggest that this link is far obvious to students. Two whole year groups of 11-year old students (n=556) attended a field course of exceptional quality, with teachers specially trained to deliver the course within a social context. The students were later asked to complete a questionnaire about the importance of protecting biodiversity. Despite the inclusion of social aspects of nature conservation, only 58% of students mentioned values. The commonest anthropocentric values mentioned were in relation to human health and wellbeing, although a substantial number of these students raised an apparent misconception that biodiversity plays an important role in producing oxygen for humans, with no consideration that a monocultural plantation might generate just as much oxygen. The questionnaire was also given to local ecologists, and they included some values which did not feature in any of the students' responses, notably cultural values, spiritual values and political values. These students appeared to have very little cultural connection with their local natural forest. The paper proposes that school ecology and biodiversity courses should include teaching about anthropocentric values, such as links to local culture, economics and politics, and these aspects need to be taught explicitly for students to recognise their importance.

# Dealing with Teleological Explanations – A Language Issue in Evolution Classes?

*Helge Gresch*

**Keywords:** evolution, teleology, Lamarck, argumentation, students' conceptions, documentary method

**Type of presentation:** Poster

Teleological explanations are often considered a central obstacle in understanding and explaining evolutionary processes, in particular natural selection and adaptation. Rather than offering ultimate causal reasons, students often explain evolutionary change by referring to the function of a specific trait and the need of the organism to adapt, and thereby imply goal-directedness and purpose. Furthermore, the use of teleological formulations is a matter of subtle language differences. Although many studies have investigated students' use and acceptance of teleological explanations in questionnaires and interviews, it has not yet been examined, which role teleological explanations play in the classroom and how teachers deal with them. Therefore, it was investigated in this study in which ways teleological explanations are addressed in student-student and student-teacher interactions in secondary school evolutionary classes. In particular, this study focusses on the way teleological explanations are addressed as a language issue. Seven evolution units about adaptation were videotaped for this purpose (grades 7-13, 36 videotaped 90min-periods). The videos were analyzed using the documentary method, which allows to examine both, the immanent or literal meaning (what is said) and the documentary meaning (how it is said) by reconstructing the organization of classroom discourse. Different types of dealing with teleological explanations were reconstructed through comparative analyses. In all evolution units, teleological explanations of the students were observed and addressed in the classroom. In this presentation, the focus will be on two types. In the first type, the teacher shows a scientific orientation and refutes teleological formulations on two levels: as a matter of precise scientific language use and as a misconception of the students. She constructs a difference between explanations of Darwin's evolutionary theory as scientifically correct and Lamarck's evolutionary theory as scientifically wrong. Thereby, she parallels Lamarck's theory, students' conceptions and wrong teleological formulations. In a second type, the teacher uses examples of the students' world that enforce teleological formulations of the students and the teacher. The process of adaptation is presented in a need-based conscious way of individual organisms. We suggest for biology education practice to address the difference between causal and teleological explanations on a metacognitive level and to sensitize students for scientific and teleological language.

# **Learning and teaching with rubrics (Kompetenzraster) - Development and evaluation of inclusive learning environments in biology classes to foster students' success and motivation**

*Marlen Grimm and Carolin Retzlaff-Fuerst*

**Keywords:** inclusion, basic needs, differentiation, rubrics (Kompetenzraster), mixed methods

**Type of presentation:** Poster

According to the Self-Determination Theory of human motivation all humans have the same three psychological basic needs which consist of autonomy, competence and relatedness (Deci & Ryan, 2000). Through the study of these basic needs in the context of biology classes, this research project contributes to the key question of inclusion, i.e. how education can meet the needs of all students involved. The use of rubrics (Kompetenzraster) allows on one hand, to meet the demands for individuality and goal differentiation as well as on the other, maintaining the competence orientation and general educational standards (Schwager & Pilger, 2015). Based on current findings regarding the construction of rubrics (Kompetenzraster) (Krille, 2016) one rubric (Kompetenzraster) was developed along with relevant study materials for a 6th grade lesson unit on invertebrates. This was then tested throughout the school year 2017/18 in the form of a learning office (Lernbüro) in three classes (total sample: N = 94, control group: N = 24) and evaluated with regard to the impact on the students' learning success and motivation. As part of a Mixed-Methods-Design, standardized questionnaires and participatory observations were used. In addition to measuring the basic needs, these served to determine a qualitative sample for semi-structured interviews at the end of the learning unit. At the ERIDOB 2018 first test results of the learning success as well as the subjective perception of students with regard to the fulfillment of their basic needs will be presented. Further, first trends from triangulation of questionnaire, observation and interview data will be discussed.

# The effects of autonomy-supportive and controlling teaching behavior on students' goal orientations in biology lessons

*Nadine Großmann and Matthias Wilde*

**Keywords:** Self-Determination Theory, teaching behavior, goal orientations, nutrition

**Type of presentation:** Poster

In biology education, students' motivation decreases during secondary school. One important perspective on students' motivation is described in the goal orientation theory. In this theory, two major goal orientations are distinguished: a mastery and a performance goal orientation. A mastery goal orientation focuses on understanding and improving skills. Students with a performance goal orientation on the other hand strive to demonstrate competence (approach) or hide a lack of ability (avoidance). In comparison to a performance goal orientation, a mastery goal orientation has been found to be more beneficial for students' engagement and learning success. Fostering students' mastery goal orientation might be especially important for topics in biology that are essential for the students' everyday life, in particular their health.

Autonomy-supportive teaching behavior in the sense of Self-Determination Theory can influence students' motivation in biology lessons positively. In biology education, the diversity of methods and contexts that i.a. relate to the students' own body and their everyday life is especially suitable for the implementation of autonomy-supportive elements like providing choices and rationales. These elements may have an impact on students' mastery goal orientation. On the contrary, learning environments that frustrate students' need for autonomy might foster a performance goal orientation due to a pressuring, competitive and externally regulated learning climate. Based on these assumptions, we designed a study to investigate the students' mastery and performance goal orientation in learning environments that foster and thwart the students' perception of autonomy, respectively.

In our study, 215 students ( $11.49 \pm 0.56$  years; 52% female) participated in four biology lessons dealing with the topic nutrition. Five classes were taught by an autonomy-supportive teacher whereas four classes had a teacher who behaved in a controlling manner. The varied teaching behavior related to different elements of the lessons like the teachers' language and feedback as well as offering choices and providing rationales. Students' goal orientation was assessed before and after the intervention. Furthermore, their perceived autonomy was measured after the intervention. Significant differences in the students' perceived autonomy were found in the comparison of both treatments. Our analysis further revealed significant differences in the students' mastery goal orientation, but not in the performance-approach and performance-avoidance orientations. Against our assumption, an autonomy-supportive teaching behavior did not foster the students' mastery goal orientation. Instead, the students' mastery goal orientation decreased in the learning environment with controlling teaching behavior.

# Academic Self-Concept and its Relation to Achievement – Biology-Specific or Science bound?

*Jörg Großschedl, Virginia Welter and Ute Harms*

**Keywords:** achievement, dimensional comparison, self-concept, social comparison, students

**Type of presentation:** Oral

Life sciences are an important factor ensuring growth and long-term sustainable prosperity of modern societies. Thus, predicting academic achievement in biology and the related science subjects chemistry and physics becomes an important goal for educational research. Students' academic self-concept is an influential predictor for academic achievement. Referring to the Internal/External frame of reference model, the formation of students' self-concepts depends on (1) social comparison processes which imply that students compare their achievements in one subject with those of their classmates in the same subject and (2) dimensional comparison processes which imply that students compare their achievements in one subject with their achievements in another subject. Social comparisons result in positive correlations between achievement scores and self-concept scores in a particular subject, whereas dimensional comparisons can cause negative (in case of very different subjects) or positive correlations (in case of very similar subjects) between achievement scores in one subject and self-concept scores in another. We assessed the academic self-concepts of N=2064 Vocational Education and Training (VET) students in biology, chemistry, and physics as well as their academic achievements in these subjects. The VET programs considered in our study prepare students for biology-, chemistry-, or physics-related jobs. As there is little knowledge about the structure of academic self-concept in science, the first aim of our study was to investigate whether students' have empirically separable self-concepts in biology, chemistry, and physics or a single self-concept in science. As the formation of self-concepts in the three science subjects is also unclear so far, the second aim of our study was to draw empirically founded conclusions about the existence of dimensional and social comparisons in the formation of these self-concepts. Results show that students' self-concepts in biology, chemistry, and physics are empirically separable constructs. Structural equation modeling shows positive and significant correlations from achievement scores to self-concept scores within a particular subject (biology, chemistry, or physics), which indicates social comparisons. However, only the cross correlations from achievement scores in biology (and chemistry) to self-concepts in chemistry (and physics) are positive and significant indicating dimensional comparisons and positive effects of achievement in one subject to self-concept in another. Our results imply a differentiation between subject-specific self-concepts in science and suggest considering students' self-concepts in biology, chemistry, and physics as meaningful predictors of students' achievements in these subjects. Differential effects between the three subject-related VET programs are presented at the conference.

# Inconsistent representation of alleles' symbols in textbooks

*Michal Haskel-Ittah, Ravit Golan Duncan and Anat Yarden*

**Keywords:** Genetics symbols, Alleles, Textbook

**Type of presentation:** Oral

Studies have shown that genetics is a challenging domain both for teachers and students. Students experience difficulties in understanding genetic concepts and the relationships between these concepts. One concept that has been shown to be a major source of confusion is the concept of allele. Alleles are entities at the sub-micro level that are represented by symbols to explain macro level phenomena. Unlike symbols of alleles in science, in learning materials aimed for the secondary school level alleles are represented by various types of symbols that vary according to their context of use. In this study we analyzed seven genetic textbooks from three different countries in order to map the symbols that are used in these books. We found inconsistencies in symbolizing methods both along and between textbooks. Alleles are represented by different symbols (E.g. , A,a or A<sub>1</sub>,A<sub>2</sub> or A,B) dependent on the context and always without any explanations for the reason behind the certain symbolizing method. Symbols are related to their representational objects by means of convention. In order to construct meaning out of symbols, the observer must be aware of these conventions. Therefore, confusion can occur when there is no conventional symbolizing method and no explanations regarding cases in which changes in symbolizing methods are used. Apart from mapping the variety of symbolizing methods we are also discussing possible affordances and constraints for each one. For example: the symbolizing method of upper/lower case letter (A,a) was the only one existed in all textbooks in the same manner. It is also very simple since it consists of only one letter. However, it suggests that there are only two possible alleles for each gene and that dominance is the property of the allele in isolation and does not reflect its relationships with other alleles. These alternative conceptions were previously characterized. This study is the first step in finding a conventional method for symbolizing alleles which might support students understanding of this concept.

# The scientific clarification as the central task of lesson content design

*Theresa Heidenreich and Harald Gropengießer*

**Keywords:** scientific clarification, model of educational reconstruction (MER), critical thinking, lesson content design, teacher professionalism

**Type of presentation:** Poster

Planning fruitful lesson content structures is among the most central tasks of teaching. Since scientific literature often contains misleading terms and even scientifically wrong formulations, it cannot be used without closer scrutiny as subject matters for instruction. Science teachers therefore need to critically examine scientific content from an educational perspective. The scientific clarification is one way of systematically dealing with this problem. As one of the three research tasks of the model of educational reconstruction (MER), clarifying scientific content for instruction involves working out core conceptions of the respective biological topic. These conceptions should be scientifically adequate and intelligible for learners. Thus, it is necessary to equally consider scientific ideas and students' ideas about a biological topic for the design of instructional content structures. Yet, preservice biology teachers find it difficult to critically formulate the core ideas of scientific texts and clarify content for instruction. Often, they lack a critical and reflective disposition towards scientific literature. Moreover, they tend to assume that summarizing the main aspects of a biological topic is sufficient for instruction. These findings are based on a small pilot study on how preservice biology teachers basically conceptualize the scientific clarification. Therefore, one task of this study at hand is to systematically work out the procedure of the scientific clarification. Based on respective literature and expert interviews, we work out necessary skills, thinking dispositions and the involved analytical tasks of critically clarifying instructional content. In qualitative interviews with preservice biology teachers, it will be examined, in how far they are able to clarify content for instruction. In our study, we deal with biological topics like blood circulation, osmosis or digestion that are relevant both in the school and university context. Based on these results, learning interventions will be developed. Within case studies and more qualitative interviews with preservice biology teachers, it will be examined and evaluated what kind of learning arrangements help them develop the relevant competencies for successfully carrying out the analytical steps of the scientific clarification in the context of lesson content design.

# Decision-making competence regarding the possibilities of genome editing

*Laura Maria Heinisch, Corinna Hößle, Ulrike-Marie Krause and Wiebke Rathje*

**Keywords:** decision-making, genome-editing, students' values, students' attitudes, paper-pencil-test, intervention study

**Type of presentation:** Oral

The CRISPR/Cas9 technology is proclaimed as one of the greatest innovations in molecular biology since the polymerase chain reaction. In addition to the euphoria of the versatile possibilities of this new genetic engineering technique, also critical voices about ethical considerations are raised. Even Emmanuelle Charpentier and Jennifer Doudna, key inventor of the CRISPR/Cas9 technology, have called for a voluntary moratorium on research and clinical application of human genome modification. Genome editing has triggered a lively public debate as to its ethical tenability, in which adolescents should take part, especially in light of the fact that they might use this technology in the future.

To facilitate participation of adolescents in public debates, the competence field of decision-making is fixed as a part of the educational standard for the natural science curriculum in Germany. Based on the discipline of biology, the competence field focuses on the recognition and decision making of biological facts in different contexts. The Oldenburg model of decision-making competences follows from previous work in moral psychology, the philosophy and didactics of philosophy and was used in bioethical and medical ethical contexts. It is a structural model displaying eight sub-competences, each describing three levels. The sub-competences include perception and awareness of moral relevance, perception and awareness of sources of the own attitude, assessment, judgement, argumentation, consequence reflection and change of perspective as well as basic ethical knowledge with regard to a bioethical context.

Based on a paper-pencil-test with open questions on accounts of authentic ethical dilemmas regarding genome editing, the above-mentioned sub-competences of the decision-making competence is recorded in a pre-post-test-intervention study of 50 adolescents aged 15-18 years. Therefore, an intervention with teaching material is created with results of the preliminary study. In the preliminary study lacks of competences in dimensions consequence reflection, change of perspective and assessment are proved.

The responses of participants are analyzed using the structured qualitative content analysis according to Mayring, in which specific levels of the respective sub-aspects of the decision-making competence are assigned. When analysing the test responses, points are awarded for the dimensions of decision-making competence. The test scores collected for each test subject allow quantitative analysis of the pre- and post-test results of the study. First results of the study shows, that the decision-making competence is improved by the intervention. Especially the three dimensions with the detected lacks in competence show a rise.

# Comparison of student primary literature reading approaches to a deep and surface learning model

*Kirk Hepburn, Emily Leaman, George Ogolo, Tamunoibim Sambo and Nienke van Houten*

**Keywords:** primary literature, reading comprehension, science process skills, assessment of student learning, instructional innovation, attitudes and expectations, deep learning

**Type of presentation:** Oral

Developing critical reading skills of primary literature, such as journal articles, is a cornerstone of becoming a scientist. There is a substantial body of research that describes learning models of student reading comprehension, but there is a scarcity of literature that explores how these models relate to primary literature interpretation. In this investigation, we compared approaches taken by students when reading a life sciences journal article to a deep vs. surface learning model (Marton & Saljo, 1976). We recruited 8 novice and 11 experienced health sciences undergraduate students to demonstrate their reading approaches in a 3-step interview approach. We first categorised the interviews according to the types of evidence that students used to answer the written question “find two main points of the article and identify supporting evidence for those points”. Performance categories ranged from broad superficial descriptions to making concise conclusions that referenced specific figures as evidence. Students in the middle of the spectrum made accurate conclusions, but the supporting evidence was absent or text-based. We then examined the think-aloud portion and the semi-structured interview questions for behaviours shown by students in the different performance categories and whether they engaged in “deep” or “surface” approaches. Questions included: describe for us the approach or strategy you used for reading this article; what other strategies could you use to improve your understanding of the article; and, which section of the article was most important for your understanding? We observed that the majority of students relied on text to find information and avoided independent interpretation of data found in figures. This aligns with surface approaches to reading, for example, skimming text in discussion section for the main point. In addition, they avoided methodology and resisted interpreting statistics, even if they had taken biostatistics courses. Students who referred to figures and data as evidence used approaches that were consistent with deep learning (e.g., reading for understanding). Taken together, these results suggest that interpretation of journal articles aligns with a deep vs. surface learning model, but teaching this skill will require design of assessments that emphasize independent interpretation of data, figures, methodology and statistics. Ultimately, these data will be used to direct learning experiences that will enhance student reading skills of primary literature.

# **Diagnoses of teachers regarding students' strategies when addressed as moral subjects in the context of ESD**

*Anne-Katrin Holfelder*

**Keywords:** Education for sustainable development, Environmental education, diagnostic competence, decision making

**Type of presentation:** Oral

Education for Sustainable Development (ESD) has not only the aim to promote competencies regarding decision making but also regarding actions. One challenge here is the criticism on indoctrination. Empirical studies indicate that the teachers' conviction in terms of individual actions influence their didactical orientation. Students apply different strategies when they are implicitly addressed as moral subjects who should act sustainable. As little is known about the diagnoses of teachers regarding the students' coping strategies, the focus of this study is the reconstruction of those diagnoses. The aim is to identify different types of diagnosing the students' coping strategies in order of the understanding of sustainability and the own role. In semi-structured and problem-focused interviews, biology teachers are confronted with audio sequences from students discussing sustainability related decisions in terms of their individual role. The sequences represent different strategies coping with the implicitly built up need for individual action. Implicit knowledge is considered as the relevant knowledge structure as it forms the basis for judgements and actions and gives orientation in everyday actions. Therefore the study refers to the methodology of the documentary method which aims for the reconstruction of the implicit knowledge structures.

# Natural history dioramas for teaching biodiversity on an ecosystem level: Programme for pre-service biology teacher education

*Špela Hrast, Ljerka Trampuž, Staša Tome, Sue Dale Tunnicliffe and Gregor Torkar*

**Keywords:** non-formal education, natural history diorama biodiversity, pre-service biology teacher, ecosystems, natural history museum

**Type of presentation:** Oral

Natural history dioramas are life size representations of the natural world, classically containing taxidermically prepared animals in a reconstruction of their habitat. In the present research dioramas from the Slovenian Museum of Natural History in Ljubljana were used. In the museum are six dioramas representing typical ecosystems in Slovenia: forest, Alpine, carst cave, marsh and two coastal sea dioramas. The museum is the most important institution for authority for acquiring, conserving and exhibiting natural history collections and non-formal educational institution for promoting natural heritage in the country. A programme for pre-service biology teachers, studying at the University of Ljubljana Faculty of Education, was developed in collaboration with the museum to teach students how to implement dioramas for teaching biodiversity on an ecosystem level and to raise their awareness of roles the museum could have for biology education. The programme based on a students' project work was named 'Dioramas for biodiversity education' and included planning, preparation, implementation and evaluation of the lessons using dioramas. The purpose of the present study was to evaluate the programme from the perspective of pre-service biology teachers and their gains. Secondly, we evaluated the programme from the content perspective; possibilities of using six dioramas for teaching biodiversity on an ecosystem level recognized by pre-service biology teachers. Analysis of the lessons showed that pre-service teachers mainly recognized usability of dioramas for teaching students about interspecies relations, food chains and webs, abiotic environmental factors, and animal adaptations. The majority of pre-service teachers reported that experience of the programme is going to help them better implement dioramas as well as the use of non-formal educational institutions, such as Slovenian Museum of Natural History, into their future work in school.

# Processes of professionalisation – Outdoor teaching and assessment of PCK

*Lissy Jäkel, Sabrina Frieß, Ulrike Kiehne and David Hergesell*

**Keywords:** Outdoor education, Pedagogical content knowledge, Education for sustainable development

**Type of presentation:** Poster

Our contribution analyses and empirically tries theoretical concepts that relate to outdoor education. Education for Sustainable Development (ESD) demands the possibility of practicing ‘shaping skills’. Shulman already distinguished areas of professional knowledge, of which three are particularly important: specialised content knowledge (CK), didactical knowledge related to the subject (PCK) and pedagogical knowledge (PK). Today, Shulmans theories are represented by the PCK model (e.g. Baumert and Kunter). We extended this highly topical model for the professionalism of teacher action by adding the component outdoor learning.

Our team is working to develop and improve tests to find out whether the university training of future teachers is progressing successfully. Our instrument uses standardised items to determine PCK components, that are domain-specific for nature-based outdoor education and especially for school gardening. It was, however, necessary to improve the scale quality as well as clear away some of the items. The test is divided into three complexes:

- a) Attitudes towards nature (Cronbach’s  $\alpha = 0.714$ )
- b) Self-assessment of one’s knowledge and didactical competence with regard to one’s capacity for field work (Cronbach’s  $\alpha = 0.866$ )
- c) Assessment of the possibilities (Cronbach’s  $\alpha = 0.804$ ) and limits (Cronbach’s  $\alpha = 0.772$ ) of field-work during lessons

Pre-service student teachers at our university focus on professional requirements already while studying. For this purpose pre-service student teachers are given the possibility of learning how to treat subject matter learning with children for twenty years now. This includes reflecting on their actions in outdoor learning settings – especially in school gardens. We assessed the development of PCK for outdoor teaching using various methods. We were able to show that specific increase was noted where the focus of the seminar themes was set (rather subject-oriented, rather teaching process oriented) and that no measurable transfer effects occurred between these.

After more than two years of measurements with our outdoor PCK-test it appears that further items are needed for the domain-specific recording of PCK in the area of outdoor teaching. We particularly wish to separate the areas gardening competence and working with children outdoors. Nevertheless we are trying to implement items with regard to ESD into the existing assessment.

# Scientific posters within BIODiver project: formative assessment in undergraduate primary teachers' courses

*Isabel Jiménez Bargalló, Arnau Amat Vinyoles and Jordi Martí Freixas*

**Keywords:** biodiversity, formative assessment, undergraduate teacher education, inquiry skills

**Type of presentation:** Poster

We present features and results from a pre-pilot study investigating the development of scientific inquiry skills and practices by undergraduate primary teacher students. Research has been done within the framework of BIODiver, a project that seeks to promote school scientific research of the local biodiversity in school environments. We describe specific pedagogical approaches used to guide preservice teachers to develop an understanding of the experimental skills required to perform a scientific investigation. Specifically, we focus in the use of scientific posters developed by undergraduate students as a formative assessment strategy for promoting and measuring undergraduate students' understanding. We report interim results from the qualitative analysis of preservice teachers' posters, showing its usefulness to provide evidence of students' developing capabilities as well as insights into challenges or incomplete understandings. Conclusions regarding the utility of such formative assessment methodologies are given.

# The history of biology and the promotion of good questions in the learning of the plasma membrane

*Carol Joglar, Sandra Patricia Rojas R. Rojas, Ricardo De La Fuente and Veronica Astroza*

**Keywords:** questions, plasma membrane model, history of science, learning of science

**Type of presentation:** Oral

At present, the formulation of good questions has stopped being an exclusive necessity of teachers and now it is also a necessity of students. If related to the history of science in contexts of the learning of complex and abstract models, such as the plasma membrane model, the design of questions can be an effective strategy for identifying obstacles to learning and for promoting scientific thinking. This study seeks to characterize questions generated by high school students, both individually and as a group. These questions were generated using a didactic instrument that was based on historical moments in the development of the plasma membrane. The results show that students generate predominantly open-ended questions, and that the questions proposed by groups of students have a better cognitive level than the questions made individually. Despite this, the questions remain at basic levels with respect to scientific explanation.

# **Fostering prospective biology teachers' diagnostic competence – Effects of an intervention on basic diagnostic skills**

*Tobias Alexander Joos and Ulrike Spörhase*

**Keywords:** Biology teachers' professional development, Diagnostic competence, task analysis

**Type of presentation:** Oral

Performing diagnostic activities during lessons represents an essential task in teachers' daily work routine and is furthermore part of teachers' professional competences. In the context of basic diagnostic skills, teachers have not only to be able to evaluate student achievement, but primarily dispose of possibilities to gather information about their students. To adequately select, evaluate and develop suitable tasks as diagnostic instruments, teachers are supposed to identify task requirements based on their biological content (CK) as well as their pedagogical content knowledge (PCK). In order to train prospective biology teachers' diagnostic competence, we developed a theory- and evidence-based academic training, which focused on the handling with tasks for the purpose of diagnosis. Upcoming biology teachers in their academic stage (n = 55) participated. The intervention was evaluated using questionnaires and problem-centered group interviews. With respect to participants' self-assessment in the range of "teaching" and "diagnosing", a comparison of mean values shows for both scales an increase towards the end of the intervention. The results of the questionnaires as well as the interviews refer to a sustainable promotion of diagnostic competences.

# Assessing professional vision of biology teacher students

*Friederike Kaiser and Philipp Schmiemann*

**Keywords:** formative assessment, scientific inquiry, professional vision, professional development

**Type of presentation:** Oral

Formative assessment is of great importance as it contributes to the quality of science education. However, implementing it in class turns out to be difficult for teachers. The actual performance of formative assessment is rooted in situation-specific skills. These skills are highly influenced by content knowledge (CK) and pedagogical content knowledge (PCK). Situations-specific skills include the aspects professional vision and decision-making. This study focuses on professional vision with its components perception and interpretation. Professional vision is of particular importance in identifying elements of formative assessment for supporting the learning process in challenging fields like scientific inquiry. The major aim of this study is to prove the validity of a test instrument concerning professional vision focusing on teachers' formative assessment in context of biological experiments. For this an online text vignette based instrument was conceptualized. The items reflect the two components of professional vision: perception and interpretation. We used an expert rating as an external reference for our analysis. To verify the sensitivity of the instrument a training with two phases was conducted fostering the professional vision of biology teacher students ( $N = 29$ ). In the first phase, theoretical work concerning scientific inquiry, typical pupils' mistakes when conducting experiments, and formative assessment was at center. In the second phase the participants supported pupils when conducting biological experiments in the lab. Before and after both phases students performed our vignette test. In addition, CK and PCK regarding scientific inquiry were also assessed. The reliability of the scales professional vision ( $\alpha = .89$ ), CK ( $\alpha = .71$ ), and PCK ( $\alpha = .65$ ) range from good to acceptable. A repeated measures ANOVA was conducted. It reveals an increase in professional vision with a moderate effect size over the three points of measurement ( $\Delta M = .07$ ;  $SD = .14$ ;  $F = 3.687$ ;  $p = .031$ ;  $\eta^2_{\text{part}} = .116$ ) and a main effect from pre to post. Furthermore, the increase of both CK and PCK are correlated to professional vision (CK:  $\rho = .63$ ;  $p < .01$ ; PCK:  $\rho = .53$ ;  $p < .01$ ). Hence, the increase in professional vision induced by our training program could be interpreted as an indicator for the sensitivity of our instrument. The correlation of CK and PCK performance and the increase in professional vision support the construct validity of the newly developed instrument.

# Storytelling as an educational tool in biology teaching: a pilot study

*Nausica Kapsala and Evangelia Mavrikaki*

**Keywords:** storytelling, student engagement, History of Science, Nature of Science

**Type of presentation:** Oral

Storytelling is a core human characteristic that describes the way we think, dream, construct our knowledge of the world, communicate, and learn. In science and in biology teaching, it may facilitate the introduction of history and philosophy of science in the teaching context promoting cultural content knowledge and Nature of Science (NOS) understanding. We present a case study concerning an experimental teaching strategy that involves storytelling followed by conversation, which was applied to teach the concept of bio-accumulation to 16 years old Greek students. The story told is “The silenced robins” about the incident of dying robins in 1955 and George Wallace’s research that led to the ascertainment that DDT had poisoned them. It was chosen because it concerns an environmental issue, and it can lead to the discussion of several sociocultural and NOS topics. Our research questions refer to how students evaluate the storytelling teaching method, whether it helps them with conceptual understanding, whether it affects their engagement and the climate of the class, and whether telling a story derived from the History of Biology raises NOS issues. Two weeks after the intervention a questionnaire was delivered to the students, which consists of 3 attitudes’ subscales that evaluate the biology lesson with and without storytelling and storytelling as a teaching method. Data were analyzed with the @IBM SPSS 22. The means for each subscale were estimated. Paired samples t-test was used in order to look for differences in students’ attitudes as a whole and for each statement ( $\alpha=0,05$ ). The reliability of the questionnaire was estimated as very high. Students were positive towards storytelling as a teaching method in biology ( $4.02\pm 0.52$ ) and appraised it more than lessons without it ( $t=7.67$ ;  $df=44$ ;  $p=0.00<0.001$ ). They liked it more than the usual lesson, and found it more interesting, claiming that the story makes scientific concepts understandable and helps them to better remember schoolbook theory. Moreover students found the storytelling biology lesson participatory and interactive. As far as the climate in class is concerned, students found their teacher more approachable and relaxed during the storytelling lesson. Finally, they claimed that the storytelling lesson helped them better understand about science and scientists themselves and they answered that it stirred their curiosity in science, scientists and great discoveries. Our research questions were positively answered by this case study. The storytelling method should be tested again with a broader sample.

# Combining biology education & education for sustainability in preschool: Insights from the 2nd cycle of a design research study

*Maria-Christina Kasimati and Marida Ergazaki*

**Keywords:** Early Childhood Education for Sustainability, early biology education, 'possible futures' approach, design research

**Type of presentation:** Oral

With serious environmental, economic and social problems undermining a sustainable future for the mankind, there is an urgent need to make Education for Sustainability (EfS) a high priority everywhere. However, the relevant literature indicates that research about EfS in Early Years (ECEfS) is limited. Biology Didactics can pinpoint to concepts that might fit in the context of ECEfS, whereas at the same time they are important for young children's ecological understanding. Combining biology education and ECEfS seems to be worth-trying. Thus, our study addresses the question of whether it is feasible to design a learning environment that could support preschoolers in enhancing their conceptual understanding about nature, along with their socio-environmental awareness. Here we're particularly concerned with identifying whether/how preschoolers' understanding about our target ecological and socio-environmental ideas has changed within the 2nd version of our learning environment - 'part A' (in short, LE2A). The latter, which was developed by considering the 'possible futures'-approach, was tested in the case study we performed in the 2nd research cycle of our design research. The participants of this case study were fifteen, conveniently selected preschoolers (age 4.5-5.5). They were divided in three five-member groups. Each -mixed age/mixed level- group took separately part in five, 20-30-minute sessions in a three-week period. All sessions were guided by the scenario of a city that faces a serious unemployment-problem and decides to cut down its huge forest, so that people could be employed as wood-cutters/sellers. However, this triggers a globally problematic future that needs to be collectively dealt with. Activities of several types (e.g. story-telling, scaffolded-dialogue, puppet-show, role-playing) were attached to this scenario, so that all the target-ideas would be introduced. Children gave pre/post, individual, semi-structured, 20-minute interviews. The questions concerned our socio-environmental target-ideas ('present-future', 'equality', 'local-global', 'individual-collective'), as well as our ecological ones ('forest impact on abiotic environment and human life', 'habitat', 'food chain'). They were also integrated in a scenario similar to that of LE2A. The tape-recorded interviews were transcribed and analyzed in 'NVivo'. Children's responses to each question were coded as 'naïve', 'transitional' and 'informed. According to our findings, LE2A seemed to work quite well regarding the ecological target-ideas and the 'present-future' relationship. Nevertheless, it does need further elaboration so that the socio-environmental target-ideas, which are of key importance, could be met as well.

# **Influence of Role Assignment on Student Activity during Cooperative Inquiry Learning in Science Class**

*Katrin Kaufmann and Andrea Moeller*

**Keywords:** inquiry-based learning, cooperative learning, laboratory groups, assigned team roles, student activity types

**Type of presentation:** Poster

In science class, students often work cooperatively in groups when engaged in inquiry-based learning, which can present challenges due to group dynamics and hence influence learners' achievement. Moreover, group dynamics in inquiry-based learning in science context is also challenging for teachers. Therefore, structuring of the group process is commonly recommended. One possibility for structuring the group process is the assignment of specific roles to each group member, e. g. being a time keeper. In our study we asked the following research questions: Which effect has role assignment during inquiry learning in cooperative science laboratory groups on (1) students' activity types (SATs), and (2) on students' perception of cooperative learning processes in different age groups?

440 secondary school students (grade 5-8, 54 % female) took part in a half-day inquiry-based biology intervention in an out-of-school laboratory, working in teams of four on four inquiry activities with the Vietnamese Walking Stick insect (*Medauroidea extradentata*). In the experimental group (n = 216), each student rotated through four roles (e. g. moderator or time keeper), while the control group (n = 224) worked on the same activities without assigned roles. Data was recorded by external observers and assessed with questionnaires. In grade 5/6 regardless of role assignment we found two activity-oriented SATs, High Experimenter and Allrounder. In contrast, we observed additional Passive and Distracted Students in grade 7/8, depending on whether roles were assigned or not. Role assignment in grade 5/6 had no influence on perceived cooperative learning, while 7/8th graders reported higher cooperative learning behavior with assigned roles. Both results suggest age dependent effects of role assignment during inquiry group learning and can provide valuable insight for structuring inquiry activities in science class. The study holds implications for teachers and other science educators who seek to identify further ways to improve science instruction for cooperative inquiry lab group work. We think that by knowing about their students' typical activity types, teachers can anticipate group processes more easily and foster cooperative inquiry work in science class.

# Supporting students' freedom during mobile-aided fieldwork in a biology lesson

*Anttoni Kervinen, Anna Uitto and Kalle Juuti*

**Keywords:** Outdoor education, fieldwork, biology education, mobile-aided learning

**Type of presentation:** Oral

Outdoor environments are considered as important authentic learning environments in biology education with several cognitive and affective benefits for students. It has been argued that during fieldwork, less structured activities and more free choice time can promote learning and positive attitudes. However, studies suggest that teachers' fear of losing control outdoors is limiting the use of fieldwork and encouraging more authoritative teaching practices. We suggest, that in order to promote student-led teaching in the outdoors and cope with the challenges in controlling the students, deeper understanding is needed on how the freedom and control are actually manifested. In this study, we explored the concepts of freedom and control in terms of how students contest the formal boundaries of science education while engaging in fieldwork activities. We focused on a selected case of a Finnish 8th grade biology lesson where students identified and took pictures of mushrooms and communicated with the teacher through WhatsApp-messages.

We video and audio recorded on group of four students during the lesson and collected the WhatsApp messages. Episodes of interaction between the students and the teacher were selected for closer analysis and transcribed. The verbal and nonverbal interactions were analyzed through interaction analysis.

According to the results, the great autonomy of the students did not lead to the loss of control. The control was maintained by combination of mobile-aided interaction and evaluation. The controlling aspects were, however, contested by the students. The freedom and absence of the teacher let students contest the relevance and authority of the teacher and instruction by for example swearing and joking. Also, the students engaged in discourse that was not related to the task at hand but to their everyday experiences outside the school, for example mobile games.

We argue, that through their diverse manifestations of freedom, the students were negotiating a learning situation that differs from the monological and suppressing sense of science learning that the classroom environment tend to produce. In this respect, the students' freedom in outdoor environment can support relevant and meaningful biology learning. The mobile-aided interaction with the teacher seem to be supportive for learning and sufficient as a controlling structure. The results of the study provide support and approaches for developing more student-led fieldwork practices in formal biology education and in out-of-school settings.

# There and back again – a journey into undergraduate students' tree thinking

*Petra Korall*

**Keywords:** tree thinking, phylogenetic trees, evolution, conceptual understanding, pre-post- and retention tests

**Type of presentation:** Oral

To understand and interpret phylogenetic trees, so-called tree thinking, is fundamental for our understanding of biological diversity patterns. However, misconceptions are common in relation to students' conceptions of tree thinking, e.g., that trait similarities indicate close relatedness and that evolution is linear ("humans are descendants from chimpanzees"). Studies evaluating students' conceptual understanding of tree thinking have among other things used pre- and post-tests, but retention over time is rarely studied.

In this study students' conceptual understanding of tree thinking in short- and long-term perspectives is evaluated using a quantitative approach. The focus is on two misconceptions: i) preconceived ideas on relationships/trait similarity reflecting relatedness and ii) linear thinking.

Students in biology at a major Swedish university were tested in a quantitative study to address students' conceptual understanding, using a design with "pre-course", "post-course" and "retention" tests. For each of the nine questions included, Fisher's exact test was used to compare i) the pre-course and post-course tests, and ii) the pre-course and retention tests.

The tree thinking tests showed significant differences between the pre-course and post-course tests for eight of the nine questions, but for only three questions when comparing the pre-course and retention tests. This indicates an overall clear short-term change in students' conceptual understanding, but also that this change was retained only to a lesser degree in the long-term. Differences were noted between the questions addressing the two misconceptions under study. Misconceptions on trait similarity and preconceived ideas seemed to affect the outcome of the pre-course test. However, the post-course test showed significantly higher proportion of correct answers in five out of six questions, and for the retention test in three out of six questions. In contrast, the three questions addressing linear thinking, although with significantly higher proportion of correct answers in the post-course test, showed no significance between the pre-course and retention tests, indicating poor retention of the understanding gained.

The two major findings presented here are that the conceptual understanding of tree thinking is only in a few questions significantly different one year after the course as compared to the pre-course test, and that the level of retention seems to be different between the two misconceptions studied. This raises further questions. Do these results apply in a broader context? Is conceptual change more difficult in relation to some of the tree thinking misconceptions? I will address these questions in further quantitative and qualitative studies.

# Learning the Control-of-Variables Strategy: What works best?

*Johanna Kranz, Tobias Tempel, Katrin Kaufmann and Andrea Möller*

**Keywords:** scientific investigations, experiments, control-of-variables strategy, retrieval

**Type of presentation:** Oral

The skill to plan unconfounded scientific experiments and make valid inferences from their outcomes is a fundamental requirement for the scientific inquiry process and hence for scientific literacy in biological education. However, students often have difficulties to identify and select variables as well as planning controlled experiments whilst making use of the control-of-variables strategy (CVS). Meanwhile, cognitive psychologists have advocated the beneficial impact of using memory tests (retrieval) as learning tools in school and university, but so far only the impact on content knowledge was investigated. Here, we conducted two studies to investigate the effect of different learning strategies on the performance of CVS:

[study I] (1) retrieval-practice (open recall) and (2) repeated studying; [study II] (1) retrieval-practice (cued recall), (2) repeated studying and (3) practical performance of an experiment with woodlice. Both studies were conducted in a post/follow-up design with high school students grade 5/6 (study I: n= 179, study II: n= 217). Students took part in a half-day intervention on soil biology. The first study shows that students, who trained CVS through repeated studying, performed significantly better in CVS than students who practiced retrieval (open recall) as a learning activity. Although the retrieval practice was less difficult in the second study (cued recall), students who trained CVS through repeated studying still performed better than students who trained with retrieval practice or those who trained CVS with conducting practical experiments. The results indicate, that learning complex concepts like CVS might not profit from retrieval practice as much as learning content knowledge. Also, the results are in contrast to students' metacognitive predictions, where they judged in both studies that conducting the experiment would be the most effective learning activity. We would like to discuss our results in depth with other researchers and practitioners.

# Effects of Scientific Literacy on School Garden as an Extracurricular Place for Learning on Understanding of Nature of Science by Pupils of Secondary Classes

*Torsten Kreher and Carolin Retzlaff-Fürst*

**Keywords:** scientific literacy, school garden, nature of science

**Type of presentation:** Poster

An aim of school education is to impart general knowledge to schoolchildren. To achieve this all subjects shall make an indelible contribution. Scientific literacy is a fundamental part of general knowledge. It is recognized by many academics and scientists for didactics and sciences that it is important to understand the nature of science (NOS) to become scientific-literate. Amongst others an understanding of NOS is gained by scientific inquiry.

This study investigates if scientific inquiry at school garden as an extracurricular place changes the understanding of NOS of schoolchildren in secondary school. Therefore the curricular biology lessons (topic ecology) will include teaching and tasks at school garden (intervention). It is planned that half of the pupils of each participating class will be taught in school garden and will solve tasks regularly and independently there. The other halves will get the same teaching and will solve the same tasks in class room. The focus of the lessons will be on scientific literacy and the understanding of NOS.

The pupils will be examined on their understanding of NOS by means of the "Views of Nature of Science Questionnaire" (VNOS-D) and an interview at the beginning and the end of the intervention period in March respectively June. At the end of the intervention same pupils will be interviewed. Additionally the paper-and-pencil-test "Seven Scales on the Nature of Science" will be applied at five times to analyze the influence of the intervention on long-term retention.

# Students of Biology Teacher Education develop diagnostic tasks and assess their potential

*Bianca Kuhlemann and Corinna Höble*

**Keywords:** diagnostic competence, diagnostic instruments, competency structure model

**Type of presentation:** Poster

The ability to diagnose student characteristics is one of the key competencies of teachers and it is a significant element of teachers' education, in order to create a foundation for future professional practice (Artelt & Gräsel, 2009). There are various instruments for the diagnosis of pupils' characteristics, such as interviews and written diagnostic tasks. Especially the latter can be used as well-prepared and ready-to-use instruments.

With student teachers in mind, the development of diagnostic tasks is an elementary step towards an accurate diagnosis. Diagnostic tasks are intended to enable teachers to identify for example pupils' conceptions and learning results (Hußmann, Leuders & Prediger, 2007). In the study presented below, qualitative research methods are applied to examine how students who become biology teachers develop diagnostic tasks and assess their potential.

A survey of these skills forms the basis of a competency development and is assigned to the professionalisation of the student teachers. Based on the first results from the surveys, it shows that biology student teachers follow different ways of developing written tasks for diagnosing pupils' characteristics. An important element for the assessment of one's own diagnostic task is the testing of these with real learning groups in a student laboratory. For this reason, student labs are used as sample rooms in the teacher training to enable students to assess the suitability of their developed diagnostic instruments. This form of student lab, which is used as a space for learning and for the accompaniment of learning processes by student teachers, is also referred to as a teaching-learning laboratory (Höble, 2014).

Finally Vignettes are generated not only from the diagnostic tasks, which are designed by the students and tested in practice but also from performance of the pupils, which are used in the lecture course.

# **Gender differences of estonian gymnasium students' biological cognitive skills within socio-scientific issue of lactose intolerance**

*Anne Laius, Helin Semilarski and Uko Viisut*

**Keywords:** biological cognitive skills, socio-scientific issue of lactose intolerance, gender differences

**Type of presentation:** Oral

A future society can be expected to face problems on how to educate young people who are capable to solve socio-scientific issues, or to make scientifically justified decisions in their' everyday life. With this in mind, it is important to develop students' scientific creativity skills, facilitating solving of problems. Also there is a need for people who can use their biological knowledge in different situations and in an everyday context (such as the issue of lactose intolerance). To analyse the gender differences in biological cognitive skills of gymnasium students, this study focuses on problem solving, decision making, reasoning and scientific creativity and biological content knowledge, measured within the context of lactose intolerance. Achievement levels of these 4 cognitive components of biology education were determined during three years of gymnasium biology studies in the beginning of gymnasium studies (the fall of 10th grade) and in the end of gymnasium studies (the spring of 12th grade). The gender differences were discovered between the cognitive skills achievement levels both in 10th and 12th grade students. The results show that students attained higher scores with tasks that measured biological content knowledge within socio-scientific issue of lactose intolerance, while the other cognitive skills were attained at lower levels. The main outcomes showed that despite three years of schooling in gymnasium, grade 10 and 12 students exhibited little gains in biological cognitive skills and in both grades the girls performed significantly better than boys.

# Understanding Reproduction in Plants

*Peter Lampert, Suzanne Kapelari, Michael Kiehn and Martin Scheuch*

**Keywords:** Reproduction in plants, Students' conceptions, Educational Reconstruction

**Type of presentation:** Poster

Reproduction in plants is an important topic in biology where botany, zoology, ecology and evolutionary biology overlap. The massive decline of pollinators in the last decades led to many initiatives trying to engage the general public to protect plants and their pollinators. These initiatives raised awareness of the importance of plant reproduction. Understanding plant reproduction however turns out to be very difficult for students as various studies about students' conceptions of the life cycle of plants show. Surprisingly, students' conceptions about the processes connecting the stages of the life cycle have not been investigated in detail until now. Therefore, the presented study focusses particularly on these connecting processes of pollination, fertilization and seed dispersal.

The study comprises three different fields of analysis about the processes in plant reproduction. First, the study analyzes students' conceptions about these processes on a large scale (N=724; 5th to 12th grade) with open-ended written tasks. Second, the study evaluates conceptions of teachers (N=30) about plant reproduction with written tasks and additional guided interviews. Third, the study analyzes textbooks about plant reproduction and corresponding chapters from school books. Analysis of these three fields will be completed in March 2018. In further steps, these three fields will be integrated and used to develop learning materials using the framework of Educational Reconstruction (Kattmann et al., 1997).

Preliminary results about students' conceptions show that they struggle to differentiate between pollination and seed dispersal which indicates that the importance of these processes is not clear. On the other hand, students show knowledge about involved vectors (wind, animals) and about key terms (e. g. seeds, nectar), which can be used as starting points for learning about plant reproduction. Preliminary results from the analysis of scientific textbooks show that many specific terms are used to describe plant reproduction making the topic very complex. Most textbooks focus either on pollination or on seed dispersal which reduces complexity. In schoolbooks however, both pollination and seed dispersal are usually covered on a few pages. Therefore, the texts in schoolbooks are compressed and include a high number of terms as first results of the schoolbook analysis show. Analysis of teachers' conceptions will start in November 2017.

Further results of the three different fields of analysis (students' conceptions, teachers' conceptions, textbooks) and the resulting implications for teaching will be discussed at the conference.

# "Capturing" photosynthesis via mobile learning

*Charalambia Lazaridou and Zacharias Zacharia*

**Keywords:** Photosynthesis, primary education, educational technology, mobile learning, extended memory

**Type of presentation:** Poster

In this study we investigated whether the use of a mobile device, especially its data recording affordances through the use of the photo and video capturing tools, enhanced fourth graders' in formulating and testing hypothesis holistically i.e. not only to evaluate/justifying the main hypothesis, but also to pay heed to auxiliary hypotheses and apparatus having a better chance of learning the right interpretation of the experimental results in photosynthesis more than the use of traditional means of data collection (i.e. sketch-making).

In our case, we allowed students to use the photo and video recording affordances of their mobile devices as an extending students' memory aid in confronting hypothesis testing as a holistic matter where there was an ability to re-access at any time the actual physical object or the phenomenon under study. The study involved identical inquiry based science lessons in authentic classes. For this purpose, we designed a pre-post experimental design study. In addition, this study followed an unconfounded experimental design, without changing the school environmental settings (i.e. use of the actual science class) and routines (e.g. same time schedule, science books, curriculum, and paper-and-pencil science notebooks) for establishing high validity. The implementation of the whole activity sequence lasted four weeks of 2 eighty minutes periods each, total 320 minutes for both conditions.

For the purposes of this study we used three different data sources. The first one concerned the paper-and-pencil, conceptual test administered before and after the treatment of the study. The second data source involved the four formative assessments and students success in posing and testing hypothesis through their series of 'wonder quest' and the third data source involved the science notebooks and their accompanying artifacts where evidences of proof of the relationship between posing and testing hypotheses was holistic rather than deductive. The data analysis of the conceptual knowledge test involved quantitative methods. For the analysis of the formative assessments and artifacts, we used qualitative procedures.

The results of this study showed that the data-capturing affordance of the mobile devices benefits students' learning, when an experiential learning activity is at the center of the learning process, more than the data-capturing affordance of traditional means does. In addition, mobile affordances when properly used, may serve in understanding the holistic connection of hypothesis and evidence in photosynthesis.

# Viewing molecular models of proteins via Jmol: Evaluating students' epistemic knowledge about models

*Ohad Levkovich and Anat Yarden*

**Keywords:** Epistemic knowledge, Protein structure and function, Molecular model, Jmol

**Type of presentation:** Poster

Scientific knowledge is composed of content knowledge, procedural knowledge, and epistemic knowledge. Developing and using models by students may develop their content and procedural knowledge, but do students understand the epistemic aspects about models while they use them? In this study, students used the Jmol software for viewing molecular models, and the study aimed to reveal high-school students' epistemic understanding while using Jmol to learn about protein structure and function. Our methodology was to observe students as they learn about protein structure and function with two computer-based tasks that focused on investigating two different 3D protein models. In this study, we focused on questions within the tasks that required the students to show an epistemic understanding about models. While answering the computer-based tasks, the discourse of two pairs was micro-analyzed and the students were interviewed following their discourse and the microanalysis. The findings show that out of four students, three students conceived the molecular model as an exact replica of the protein molecule rather than as a useful tool to think about molecular structures. One of these three assumed that the model itself is the physical entity of the protein. The flawed epistemic view about models can be explained according to the requirement of computer-based tasks to handle with all three knowledge components, while students use Jmol for acquiring conceptual understanding about protein structure and function and view the multiple representations. The many requirements may have impaired students' thinking about the nature of molecular models. In spite of the research limitations, our findings support the assertion that students' epistemic knowledge is not firm, in particular when they view molecular models. Therefore, we recommend taking into consideration the epistemic understanding of students, for achieving effective learning of the scientific practice, of developing and using models.

## **Pre-service teachers' use of research: from pedagogic soup to reflective practitioners through conjecture maps?**

*Francois Lombard, Laura Weiss and Marie Merminod*

**Keywords:** Pre-service teachers, Reflective practice, Conceptual change, Theory-practice, Educational design, Assessment, Teaching

**Type of presentation:** Oral

Pre-service teachers oppose theoretical knowledge to practice in classrooms. During training, they often respond to assignments with “pedagogic soup”: a good dose of jargon, which they imagine is expected but have no intention of implementing. This theory-practice opposition is grounded in a view of training as an application process (down from theory to practice). Schön (1994) showed that experienced practitioners do not separate theory from practice, but link theory and practice both into a circular process. This contribution discusses the feasibility and implementation of developing such skills, using ConjectureMaps (CJ-Maps) as conceptual artefacts to guide students' integration of theory into teaching designs. CJ-Maps require explicitly stating how theory would be implemented in practice, what educational effects it should produce, and what really happened in class. As pre-service teachers discussed “pedagogic soup” when attempting to implement and enact it in classrooms, they challenged and developed “theory-in-action”. We assessed their progression by comparing 4 versions of their CJ-Maps along the year-long project. We analysed 7 variables measuring coherence between original research, conjectures, implementation, expected and measured outcomes.

Variables regarding the expected effects progressed importantly after implementation in class, in contrast with the relevance of design elements that were initially high. This suggests pre-service teachers, when implementing their conjectures (the “practice”), moved from abstract predictions of their actions (the “pedagogic soup”), to more realistic, concrete expectations of their design. This suggests they moved from an initial conceptualization of teaching as focused on the actions of the teacher to a greater concern about the effects of their teaching. In conclusion this design requiring the explicitation of implicit knowledge into CJ-Maps seems to have helped pre-service teachers refine their reflection, as it required distinguishing teacher intentions, activities, and learning effects that are often confused by students. Our results suggest students could extract information from research, use it to improve their practice in class, analyse it to produce better theory on action, a clear sign of reflexive attitude. The analysis of CJ-Maps is confirmed to provide relevant information for research and to guide instruction or student progression.

# Ecosystems in science education research in the last 20 years

*Pedro Lucha and María José Sáez Bondia*

**Keywords:** Review, System thinking, Type of investigation

**Type of presentation:** Oral

Ecosystems are complex natural systems, present in the curricula of different educative levels worldwide, relevant from the biological education point of view.

In order to answer these questions: (1) How are the researches related to ecosystems, published on science-education journals? (2) What kind of students' knowledge do they focus on? (3) Which are the ecosystem-components more frequently included on these researches; a query on Web of Science was conducted to search for articles about "ecosystems", published in the research area of "education" or "science-education", by European authors, since 1997.

Preliminary results indicate that 29 out of the 72 analysed articles include "one-dimensional" researches whose goal is to diagnose students' knowledge (concepts, skills or attitudes) in relation to ecosystems. The rest include "two-dimensional" investigations where a certain tool or teaching strategy is evaluated through "measuring" increase in students' knowledge after conducting a tool- or strategy-based learning sequence.

Concepts and skills are the kind of knowledge more frequently evaluated in the researches. Surprisingly, there are only few articles dealing with attitudes of children towards science and/or the environment, among the lowest educational levels (pre- and elementary-school) and most of the articles evaluating this type of knowledge corresponds to researches conducted with high-school students.

The elements of the ecosystems more often included in the investigations are: Organism, Population, Community, relations between Biocoenosis and Biotope and Sustainability. Energy Flow, bio-geo-chemical cycles and Ecological Successions within ecosystems are complex ideas which involve abstract and microscopic concepts and/or time and thus, they are hard to understand for students. This would explain why these elements of the ecosystems are scarcely represented in science-education articles including researches conducted in pre- or elementary-school levels and their relative clustering in papers dealing with high-school level and higher levels.

# Effects of redundancy in multiple external representations on biology test performance

*Lara Magnus, Kerstin Schütte and Julia Schwanewedel*

**Keywords:** multiple external representations, redundancy, biological scientific communication

**Type of presentation:** Oral

Communication within the discipline of biology relies on the use of various external representations (ERs; e.g., texts, diagrams, graphs and tables). It is especially dependent on the use of visualizations to present phenomena at the submicroscopic level and complex biological concepts. Combinations of at least 2 external representations—that may carry complementary or redundant information—are referred to as multiple external representations (MERs). The role of redundancy in students' comprehension of MERs has not yet been sufficiently investigated. Consequently, data on how well school prepares students with regards to scientific communication in biology for university studies in biology are lacking. We therefore investigated biology majors' performance in biology tasks involving MERs as a function of the MERs' redundancy. In an experimental design,  $N = 240$  students worked on 2 biology tasks with systematically varied task material. The relevant information was either distributed between texts and pictorial representations, all relevant information of pictorial representations was repeated in the text, or the material consisted of texts without any illustrations or tables. One-way analysis of variance for one task showed statistically significant differences in test scores between all 3 groups, with the highest mean score for the text-only group and the lowest mean score for students who had to identify relevant information in pictorial representations to solve the task. In contrast, no differences occurred between the groups for the other task. Results imply that tasks' demands vary as a function of the MERs' redundancy and thereby also students' performance. In reference to secondary school biology education's objective to equip students with communication skills as part of becoming scientifically literate, further efforts seem necessary to understand how to improve biology teaching and, ultimately, students' ability to comprehend non-redundant and redundant biological MERs.

# **Nutrition education and citizenship - Individual responsibility and democratic politics**

*Claes Malmberg and Anders Urbas*

**Keywords:** Health education, Nutrition education, Citizenship education, Politics

**Type of presentation:** Oral

According to previous research, in contemporary western societies health is seen as an increasingly non-political issue. Rather than being at the centre of collective decision-making and democratic politics, health is regarded as resting on individual responsibility. In our study, we address the question of nutrition education in schools as well as the question of citizenship and democracy. The study consists of two parts: firstly, we analyse whether health – more precisely nutrition and diet – is portrayed as a political or non-political issue in textbooks for secondary school; secondly, and informed by the results from our analysis, we dissect and problematize what kind of citizenship that is constructed in textbooks. From a theoretical framework of politics, the article explores how citizenship emerges. Our findings so far show that health, and more precisely stress, is depoliticized in the textbooks.

# Using two theoretical models to measure environmental perceptions in earth education

*Constantinos Manoli, Bruce Johnson and Sanlyn Buxner*

**Keywords:** Model of Ecological Values, New Ecological Paradigm, Environmental Perceptions

**Type of presentation:** Oral

The study we examined the two-dimensional nature of the Model of Ecological Values (2-MEV, Wiseman & Bogner, 2003) in comparison with the New Ecological Paradigm (NEP) Scale's (Dunlap, Van Liere, Mertig, & Jones, 2000) unidimensional construct. The NEP places respondents on a continuum from a biocentric to anthropocentric worldview. In this view, an individual can either have a pro-environmental (biocentric) or an anti-environmental (anthropocentric) perspective but not both. On the other hand, the 2-MEV treats biocentrism (Preservation) and anthropocentrism (Utilization) as two separate and not necessarily related components. The model places individuals in one of four quadrants, rather than on either end of a continuum, allowing an individual to have a biocentric and an anthropocentric worldview at the same time. For the purpose of this study, we used data from 7544 upper elementary students from the US that participated in an earth education program. All students completed the two questionnaires (NEP & 2-MEV) two weeks before the program and one month after. As predicted, the data analysis revealed that students who scored high in Preservation and low Utilization on the 2-MEV, also had a biocentric worldview on the NEP. Similarly, those who scored low on Preservation and high on Utilization had an anthropocentric worldview on the NEP. However, the NEP failed to differentiate between the group of students who scored high on Preservation and high on Utilization with those who scored low on Preservation and low on Utilization. Both of these groups of students, while on different quadrants on the 2-MEV, they seem to cluster together on the middle of the unidimensional NEP. Evidence in the present study suggests that the NEP may not fully explore all dimensions of environmental perceptions.

# Promoting the role of data and scientific models in students' argumentation on socio-scientific issues through communication scaffolds

*Anna Marbà-Tallada and Jordi Domènech-Casal*

**Keywords:** scientific models, argumentation, Socio-Scientific Issues

**Type of presentation:** Poster

The development of scientific competence implies being able to transfer scientific models to take decisions in real contexts and situations participated by science. Using Socio-Scientific Issues (SSI) as a context in classrooms activities has been claimed as a method to deepen in understanding of scientific models, and developing scientific skills as argumentation and data analysis. However, students and teachers find difficulties with the role of scientific models in SSI. We have developed and tested linguistic scaffolds to help students improve in their argumentation in SSI and tested in students' essays 5 items related to use of scientific models, using key vocabulary, grammar connectors, using data, and discourse structure. Our results show students present difficulties in the three first items, that experience a strong improvement after using the proposed scaffolds.

# **Training pre-service teachers to approach interdisciplinary: learning Physics and Chemistry at Biology lessons**

*José María Marcos-Merino, Rocío Esteban Gallego and Jesús Gómez Ochoa de Alda*

**Keywords:** Interdisciplinary, Enquiry-based approach, Practical activities, Teacher training, DNA extraction

**Type of presentation:** Poster

A systemic view is required to solve major problems of mankind. However, the current organization of educational systems in disciplines provides a reductionist approach, suffering from the absence of interdisciplinary activities which with develop a global perspective. Good command of systemic view is particularly relevant for prospective teachers of Primary and Secondary Education, since they should be able to transmit a global perspective of science in stages of education in which courses are stated to be divided in disciplines. DNA extraction is an interdisciplinary practice, since to determine how to extract DNA from a biological sample it is necessary to relate biological, chemical and physical concepts. In this contribution, we describe an intervention focused on interdisciplinary active learning to increase the availability of practical activities for Secondary students as well as prospective teachers. An enquiry-based approach is followed to guide DNA extraction using household materials. Teacher raises several problems through open questions that students solve via discussions guided by teacher. Then, students involve in finding, interpreting and explaining some scientific fundamentals of Biology, Chemistry and Physics. The effectiveness of this educational intervention was estimated during 3 successive academic years with a sample of 388 prospective teachers (University of Extremadura, Spain) by using pretest and posttest (based on common misconceptions and TIMSS questions). Results support the hypothesis that this educational intervention favours interdisciplinary learning.

# **Long-term knowledge over one year with a student-centered inquiry-based learning module about bionics.**

*Michaela Marth and Franz X Bogner*

**Keywords:** long-term-knowledge, outreach, zoo

**Type of presentation:** Oral

An instructional module with selected bionics examples is linking technology with biology. The module was implemented in an outreach intervention in a zoo. We analyzed knowledge acquisition at different testing points: two weeks before (T0), immediately after (T1) and six weeks (T2) after participation. We re-checked a subsample of 191 for a longer period (twelve weeks (T3) and one year (T4) later). Our module was divided in two subunits; a seminar room module and an aquarium module. Knowledge acquisition increased directly after program participation and fell back after six weeks, but never dropped as low as former knowledge. Actually one year after program participation, the knowledge level stayed constant at the level achieved six weeks after participation. The knowledge before intervention showed a dependence on technology interest and social implication.

# **I won't believe it until I see it? An inquiry-based sequence on “Microorganisms” for secondary school**

*María Martínez-Chico, Farida Abou Akl Sánchez and M.Rut Jiménez Liso*

**Keywords:** Teaching sequence design, microorganism, Inquiry- Based Learning, Secondary School

**Type of presentation:** Poster

The aim of this article is to present an inquiry-based teaching proposal on Microorganisms for Secondary School level, framed on practice design-based research. Nowadays, Microbiology is present in the world due to the fact that these organisms participate in many processes related to human's daily life, however, difficulties in the teaching-learning process have been reported mainly due to these organisms at first sight, are invisible to people eyes. Given the current requirements from science educators, researchers, and policy makers regarding the need of promoting scientific proficiency for all citizens, we address the design of the sequence with an emphasis on scientific practices following an Inquiry-Based approach. The design of each activity is described and justified, and additionally, the summary of the process of design is shown.

# Approaching health issues and Europe's history and cultural heritage through differences in food and culinary representations in school textbooks

*Evangelia Mavrikaki, Nausica Kapsala and Apostolia Galani*

**Keywords:** health education, cultural heritage, culinary representations, gender representations

**Type of presentation:** Poster

Food as a cultural characteristic can tell a lot about a civilization; and culinary habits are influenced by historical and societal factors such as the role of gender in the preparation of food. Moreover, food plays an important role in peoples' health. School textbooks (ST) hold an important function in representing the role of food in each society, influencing children respectively. Therefore, representations of food and cuisine in school textbooks can be a good opportunity for teachers to interdisciplinary approach social, cultural, historical and health issues. The purpose of our research was to identify how food and cuisine is presented in school textbooks of various European countries, if there are any differences among them and how could such representations be used to approach social, cultural, historical and health issues. For this purpose, we collected school textbooks (ST) of the same subjects used in different European countries in which we searched for food and cuisine representations in text and/or pictures. Classical thematic analysis was applied and two coders were involved. Some of the thematic categories that emerged from the thematic analysis were a) "the Mediterranean diet", which is a major theme in the Greek ST but it is almost absent from the German ones, and b) "the German sausages" that are constantly present in every case red meat (and not only) is mentioned in the German ST, but not in the Greek ones. We believe that the representations of the Mediterranean diet, which has been acknowledged by UNESCO as intangible cultural heritage, give a good opportunity to promote a healthy diet and healthy dietary habits and at the same time to examine cultural and social aspects regarding the preparation of food, such as the role of the two genders in today's society and in the past. On the other hand the representations of "German sausages" can be used by teachers in an opposite way than the Mediterranean diet, as an unhealthy choice that should be rarely consumed as suggested recently by the WHO. In addition they can also be used as a means to bring to the foreground social and cultural issues and even geographical ones by considering why the sausages are so much connected to Germany: they are considered a symbol of Germany even outside the country, and they contain an important historical role in the survival of the poor during the long cold winters in Germany of the past.

# Herbarium in primary teacher education

*Irma Mavrič Gavez and Gregor Torkar*

**Keywords:** herbarium, pre-service primary school teacher, competences, botany, school

**Type of presentation:** Poster

In this paper, we define the importance of herbarium in primary teacher education to enhance primary school student's interest in, and knowledge of, plants. Slovene pre-service primary school teachers were trained to make their own herbarium. The study involved 166 undergraduate students in their second semester of four years long study programme at the University of Ljubljana, Faculty of Education in Slovenia. After making their own herbarium with ten species they completed a written questionnaire about gained knowledge and experiences. They were asked about names of the species they included into herbarium, which of those were new for them, which difficulties they had to deal with while making herbarium, if they already experienced making herbarium in primary or secondary school and which competences, in their opinion, primary school students can develop while making herbarium. The results show that students, while making herbarium, learned on average three new plant species. Three quarters of students reported having some difficulties in determination of plant species and the herbarization procedures. More than two thirds of students reported that they experienced making herbarium in primary or secondary school. Most of them in science and biology classes in primary school. Majority plan to use herbarium in their teaching practice. They see the potential of the activity in teaching primary school students about plant anatomy and species diversity, science skills, work attitudes and attitudes towards biology. To conclude, participating students demonstrated desired level of content knowledge and pedagogical content knowledge to successfully implement the herbarium into primary education, which could be beneficial in enhancing primary school student's interest in, and knowledge of, plants.

# Digitally Led Experiments - Results of an Evaluation Study with the App DiVoX

*Monique Meier*

**Keywords:** inquiry learning, experiment, multimedia learning, digital media

**Type of presentation:** Oral

Experiments as a method for scientific inquiry (Wellnitz & Mayer, 2013) offer a multitude of possible uses for mobile devices - from creating simple photos or videos to the use of a smartphone as an instrument for measurement. Digital support of experiments is especially evident in physical and chemical but not yet in biology lessons (Kuhn, Ropohl & Groß, 2017). The implementation of digital tools for the support of open-results experimental processes in biology lessons is the central goal of the presented project. For the development of a digital work- and learning-accompaniment of experimental processes the project focuses on the connection of standards-oriented requirements (KMK, 2016) with multimedia constructions/design principles (Mayer, 2005; Chandler & Sweller, 1991). DiVoX, Diagnostics in Open eXperiments, is a dual-instructional app that can be utilized by students as a learning and working instrument and by teachers as a planning instrument for experimental lessons. A high variability of content design through the use of various tools allows the user to adapt many respective scientific topics. An evaluative study with  $N=335$  ( $\varphi = 63\%$ ) 8th, 9th and 11th grade students reviewed whether the conceptual and technical settings were understandable from a student perspective, easy to follow and well structured. Study questions about the optimization of the app and its recognitional function with respect to connections of specific personal characteristics were asked after the execution of an experimental module with DiVoX. The students conducted a DiVoX-led, pre-structured experimental module, for example to investigate the vertical migration of water fleas, in small groups. Quantitative data was generated with questionnaires before and after the unit. The results show that, among other things, there is a high student interest in using the app for experiments, although there is a significant difference between the learning groups of the various grade levels ( $p=.001$ ). The interest in the app is significantly tied to how competently it is used,  $r=.49$ ,  $p<.001$ . As a one-shot-element for teaching and learning experimental competence, the DiVoX-achieved multimedia learning environment shows positive correlations on interest and competence experiences. This presents opportunities going forward for connected, experimental and long-term studies, to extend beyond a possible novelty effect (Kerres, 2002), to collect evidence about the impact of a digital learning environment for experiments.

# Instructional efficiency in an outreach lab: Model constructors versus model viewers

*Julia Mierdel and Franz Bogner*

**Keywords:** cognitive knowledge, models and modelling, mental effort, outreach learning, science education

**Type of presentation:** Oral

Hands-on experiments within molecular contexts of outreach labs aim to support individual cognitive learning. Increasingly, these efforts include the use of media to visualize the otherwise invisible. We applied a hands-on module, combining experimentation and model work. A model subunit was included to organize the experimental findings. In comparing the impact of two different model-supported approaches on cognitive achievement, cognitive load and instructional efficiency, we divided our sample (N=254) into two groups: While both were subjected to the experimental part of the module, the model constructors (n = 120) were required to generate a DNA-model using assorted handcrafting materials, whereas the model viewers (n = 134) worked with a completed commercially available school model of DNA-structure. Surprisingly, the model viewers performed significantly better regarding a mid-term knowledge increase, while cognitive load scores remained similar. Accordingly, the model viewing approach produced significantly higher scores for instructional efficiency, pointing to enhanced cognitive achievement through a more intense perception of the DNA-models' correct contents. While at the first glance our results seem surprising, implications for teaching when models come into play need consideration, and w

# **The significance of school biology in everyday life: a case of HIV/AIDS knowledge among South African schoolgirls**

*Lindelani Mnguni*

**Keywords:** Biology curriculum, HIV/AIDS Knowledge, School girls

**Type of presentation:** Oral

The prevalence of HIV/AIDS in South Africa in 2016 was highest since 2006 in spite of numerous programs, which are aimed at reducing risk behaviour, eliminating stigma and promoting disclosure about HIV infections. The South African government has mandated the integration of HIV/AIDS education in the biology curriculum. Previous research however shows that 40% of all young people living with HIV are young women. The current research explored the integration of HIV/AIDS content in the curriculum by asking the following research questions:

- i) To what extent is HIV/AIDS knowledge integrated into the biology curriculum?
- ii) What is the level of HIV/AIDS knowledge among schoolgirls?

In the first phase a qualitative method was used through an inductive analysis of the biology curriculum. Curriculum mapping was done to identify, quantify and interpret HIV/AIDS related content. In the second phase a quantitative survey method was used to collect data using a previously validated close-ended questionnaire from a group of 180 schoolgirls aged between 15 and 18 years. The questionnaire was made up of thirty questions spread equally in three sections, namely, academic HIV/AIDS knowledge, functional HIV/AIDS knowledge and self-reported behavioural preferences. The findings show that HIV/AIDS content is taught in biology in relation to the effect and management of viral diseases as well as the immune response of plants and animals against infecting microorganisms and vaccination. HIV/AIDS is also taught in explaining natural selection and evolution. HIV/AIDS content is not taught within the context of prevention and management of AIDS and related opportunistic infections that are prevalent in South Africa. Results show that enrolment in biology correlates significantly with the availability of both academic HIV/AIDS knowledge and functional HIV/AIDS knowledge. Biology students have a significantly higher academic HIV/AIDS knowledge than non-Biology students. It was also found that the functional HIV/AIDS knowledge among Biology students was significantly higher than that of non-Biology students. The significant finding of this research is that academic HIV/AIDS knowledge was generally lower than functional HIV/AIDS knowledge. This could be because functional HIV/AIDS knowledge is available to the participants through a number of other sources. What is interesting however is that Biology students had significantly higher level of both academic HIV/AIDS knowledge and functional HIV/AIDS knowledge. This highlights the significance of science in positively affecting everyday life.

# Use of Evidence by 3-4 and 5-6 year-olds: a Comparative Study

*Sabela F. Monteiro, María Pilar Jiménez-Aleixandre and Pablo Brocos*

**Keywords:** argumentation, early childhood, inquiry

**Type of presentation:** Oral

This study examines how a first (3-4 years old) and a third (5-6- years olds) year Early Childhood Education group engage in the scientific practice of argumentation in the context of a five months science project about snails. Results show that young children are able to generate and use evidence to answer questions and support their claims. Results indicate that children in ECE3 have a greater ease to use evidence than those in ECE1, which can be related to children's age and to the fact that they have been engaging in science projects for three years.

# Students' use of evidence evaluation criteria in written causal explanations about ecological interactions

*Ana E. M. Motta, Caio C. Freire and Marcelo T. Motokane*

**Keywords:** Evidence, Evaluation Criteria, Argumentation, Ecology, Science Education

**Type of presentation:** Oral

This study is framed in research about ecology learning and the use of evidence in biology classroom argumentation. Our purpose is to investigate if the students used evidence evaluation criteria, that is, took into account specific, sufficient and reliable evidence to write about ecological interactions. For this, we analyzed 18 texts produced by high school students in an argumentative context of identifying the causes of a phenomenon, constructing and evaluating causal explanations. In this task, the students examined provided data to investigate whether predation and then competition were able to explain the abundance of two plant species in two different forests. The definitions proposed by Jiménez-Aleixandre (2010) were considered to analyze the use of each criterion. Our results show the use of 89% specific evidence, 38.9% sufficient evidence, 55.6% reliable evidence considering comparisons for predation causal element and 22.2% for competition causal element, 0% articulations between both causal elements, 22.2% reliable evidence considering theoretical justifications for predation causal element and 5.6% for competition causal element. Despite citing specific evidence, a smaller percentage of students considered sufficiency or reliability in writing. None of the students articulated the predation and competition explanations, revealing a difficulty that may be associated with the complexity of the operation and also the isolated way that each ecological interaction is commonly presented in biology classes.

# The motivation level of Soweto students towards learning biology

*Dudrah Moyo and Lindelani Mnguni*

**Keywords:** Motivation, Biology, Students

**Type of presentation:** Oral

A number of factors have been cited as responsible for the poor performance in maths and science in South Africa including teacher and learner motivation, availability of resources, teacher training and socioeconomic status of learners and schools. What is puzzling however is that compared to Mathematics and Physics, Biology learners have constantly performed significantly better in annual end of school examinations. One of the factors for the good performance in biology can be attributed to motivation. Based on this, the current research investigated biology students' motivation for learning biology by asking "what is the level of motivation to study biology among biology students?" The variables explored in the study are self-efficacy, active learning strategies, science learning value, performance and achievement goal as well as the learning environment as possible factors that affect students' motivation for learning science.

A non-experimental quantitative survey research design was used in this research where a non-probability convenience sampling approach was employed to select 234 Grade 11 Biology learners aged between 15 and 18 from Soweto, South Africa, to participate. Data were collected using a previously validated closed-ended questionnaire. All statistical analyses were performed using SPSS Statistics 24.0 Ink software. The result showed a generally poor self-efficacy towards biology among the participating students. A negative motivation was detected with regards to learning strategies while for the learning value, performance goal, achievement goal the motivation was positive. The learning environment was found to affect motivation positively. Self-efficacy had a generally negative significant correlation with all the other variables ( $p > - .001$ ), whereas learning strategies correlated positively with learning value, performance goal, achievement goal and environment stimulation ( $p > .001$ ). The results show that while performance in biology is relatively high, student may some times lack motivation towards the subject. Of concern was the low self-efficacy amongst students coupled with the desire to be spoon fed. This is apparent in that some students prefer to be given all the required information rather than find it themselves. Notable also was that some student have a high value for biology even though some have ill-conceived reasons for studied biology. The environment was found to play a significant role on students' motivation. Overall, however, students were generally motivated to study biology, which may be affecting their good performance in the subject.

# Make biology relevant again! Student teachers' views on the relevance of biology education

*Justus Mutanen and Anna Uitto*

**Keywords:** biology teacher education, relevance, professional development, curriculum development, nature of science

**Type of presentation:** Oral

Biology education should be relevant for young students so that they would become interested in biology and choose a scientific career. Instructional methods and teaching strategies have an important role in making science education more relevant and in developing positive attitudes towards science. That's why teachers should have clear views about the relevance of science education. In this study, we conducted interviews and collected mind maps to examine student teachers' (N=10) views on the relevance of biology education. Finnish secondary school biology curricula were analyzed and compared with students' answers. The views on relevance were classified into nine main categories using grounded theory as methodological frame of reference. There were individual, societal, vocational and philosophical aspects expressed in both the interviews and the curricula. In the interviews, student teachers emphasized the relevance of biology for the student's own life, whereas nature of science (NOS) was expressed more often in biology curricula than in the students' interviews. Novice student teachers (at the beginning of their studies) put more value on general content knowledge, while more experienced students were more likely to mention sustainable future and societal aspects in their reasoning. Based on the results, we identified three stages in the development of the views on the relevance of biology education. Our results also indicate that student teachers would use teacher-centered strategies to make teaching more relevant for the students. This study suggests that pedagogical studies and teacher training have an impact on the students' views about the relevance of biology education. Moreover, we could find imbalance between curricula and students' views, especially concerning NOS in biology education.

# Teaching Scientific Inquiry in Biology: an Intervention Study about Mentoring for Pre-Service Biology Teachers

*Emanuel Nestler and Carolin Retzlaff-Fürst*

**Keywords:** scientific inquiry in biology as subject, mentoring, coaching, practice-based learning

**Type of presentation:** Poster

Scientific inquiry is one part of scientific literacy (AAAS, 1993). Kremer et al. show that biological inquiry processes can introduce the formation of nature of science understandings, too (2014). To teach scientific inquiry is one key part of teaching biology because scientific inquiry increases biological scientific literacy. Pre-service teachers need not only to understand scientific inquiry but also have to know how to teach this part of biology education.

The importance of the subject (e.g. biology) is stated by the expertise research (Neuweg, 2005; Baumert & Kunter, 2006). The worldwide process of improving teacher education is focused on making the teacher preparation more practice-based (Klette, Hammerness & Jensen, 2017). However, the linking process between theory and practice in teacher education needs a second step to make practice more theory-based. Expert teachers change their roles to mentors for pre-service teachers if they develop conversation techniques (Kreis, 2012), reflect their mentor-role (Hennissen, Crasborn, Brouwer, Korthagen & Bergen, 2008) and increase their conscious knowledge. Furthermore, mentors only have a slight interest to integrate content and pedagogical content knowledge in their mentoring (Strong & Baron, 2004). So mentors need a change of their attitude towards content and pedagogical content knowledge in mentoring settings. The Study about mentoring in biology teacher education outlined here is intended to help close this research gap. Some questions remain unanswered: 1. Can an advanced training for mentors help to integrate more dialogues about content and pedagogical content knowledge (e.g. biological scientific inquiry) in practice-based learning settings for pre-service biology teachers? 2. Will this dialogues support their biology teaching (e.g. biological scientific inquiry)?

In this multi-method study we train biology teachers to become mentors. They support pre-service teachers in a praxis-based learning setting which is aimed to get first practice experiences. The mentors perform this learning setting before (pre) and after (post) the qualification.

Pre-service teachers (N=52) and mentors (N=8) complete a paper-and-pencil-scale after every discussion before and after a teaching lesson. We evaluate pre- and postdiscussion lesson plans with the qualitative content analysis to triangulate this data.

# **Evolution, affect and acceptance: A psychoanalytical examination of the controversy**

*Emma Newall*

**Keywords:** Evolution, Controversy, Science and religion, Student attitude, Student acceptance, Affective dimension, Change and uncertainty, Identity, Free Association Narrative Interviewing, Psychoanalytical theory

**Type of presentation:** Oral

The teaching of evolution has been consistently associated with controversy and has been the source of a great deal of debate and research in the science education community across the world. Much of the relevant research scholarship has highlighted the significance of religious belief in this debate. Faith has been found to be a significant determining factor for acceptance or not of evolution. However little research has looked at non-faith based reasons for rejection of the scientific explanation. I propose that the concepts presented by evolution can be perceived as potentially disturbing to all; ideas about change, uncertainty, absence of purpose or plan, extinction and struggle, as well as challenges to identity arising from the emphasis on our place in the natural world alongside other animals could be provoke anxiety. Using a psychoanalytical theoretical framework I have used aspects of Free Association Narrative Interviewing to examine novice educator's unconscious and conscious emotional responses to evolutionary concepts. My findings suggest that for some, the ideas inherent in evolution reveal disturbing existential questions, irrespective of whether they have a faith or not. I propose that the affective dimension of teaching and learning about evolution needs to be considered in our approach to teaching this vital biological topic and this research highlights the importance of dialogue and trust in the classroom.

# Exploring pre-service biology teachers' experiences on a zoo trip

*Joanne Nicholl*

**Keywords:** non-formal learning, zoo education, biology pre-service teachers, socio-scientific issue

**Type of presentation:** Poster

The purpose of zoos has evolved over time. The most dramatic change over the last century to zoos is their development towards being places that promote the conservation of animals and their habitats. This research looks at the experience of thirty-three Biology pre-service teachers on a visit to London Zoo framed as a socio-scientific issue. All participants were in their final month of training as a Biology Secondary school teachers. There is still controversy surrounding zoos key role in conservation compared to their role in entertainment. This research looks at the experiences trainee teachers' draw on when supporting or refuting zoos, as well as identifying their most memorable experiences whilst at the zoo. The students' views of zoos after their visit are carefully unpicked through the analysis of students' personal meaning maps. The results show that if students refer negatively towards zoos, they refer to the size of specific animal enclosure they have directly witnessed on their visit. However, if students discuss zoos in a positive light, a broad range of examples are used to support the role of zoos, where students witness the enrichment activities for the animals, the continual improvement of enclosures, and the conservation of particular animals. In addition, the 'memorable moments' highlighted by the students were vastly different to the evidence used to support or refute zoos, where most moments identified were unexpected encounters from their day out, such as observing leaf butterflies and feeding llamas, as opposed to experiences they wanted to encounter. This research highlights the potential use of zoos as a teaching environment for considering and debating the controversial nature of zoos.

# Differences between girls and boys regarding motivational changes due to bilingual modules in biology

*Stephanie Ohlberger and Claas Wegner*

**Keywords:** bilingual modules, CLIL, biology teaching, motivation, interest, gender differences

**Type of presentation:** Poster

Across Europe, language policies of recent years established different models of bilingual education, also known as “Content and Language Integrated Learning” (CLIL), in order to promote multilingualism. The study project focuses on bilingual education (English-German) in biology, which presents a current trend in Germany. Two types of bilingual concepts in schools can be distinguished, namely bilingual branches and modules. Contrary to branches, bilingual modules include a whole class with all its students and do not choose participants based on marks and abilities. The modular concept comprises a unit of 10 to 14 lessons on a specific topic (e.g. enzymes) being taught in a foreign language, in this case English. The study’s underlying question is whether motivation for English and/or biology can be increased for certain subgroups of students (boys/girls, subject affinity) due to participation in two consecutive bilingual modules. For that purpose, a questionnaire was employed before, after and three months after the interventions including questions on interest and motivation for both biology and English, language anxiety and self-efficacy. With the help of GLMs and t-Tests evaluating differences of construct means, it was found that boys ( $n = 20$ ) and girls ( $n = 31$ ) do not differ significantly regarding their interest and motivation for English and biology, so the stereotypical assumptions do not seem to apply here. If combining interest and motivation into a new variable called ‘affinity’, gender interaction effects could be found for the biology affinity ( $F(3)=2,564$ ,  $p=0,057$ ,  $\eta^2 = 0,051$ ). At the beginning of 2018, another course of modules will start, so the sample size can be expected to be higher at the time of the conference. If the study provides evidence that bilingual modules increase the students’ interest and motivation for one or even both of the subjects and aligns gender differences in the motivational context, the creaming effect of bilingual branches could be avoided and the general necessity of bilingual branches questioned.

# First steps in Researching the International Biology Olympiad: Analyzing what IBO Exams Assess

*Sebastian Opitz, Jasmin Colakoglu and Ute Harms*

**Keywords:** Gifted education, Extracurricular education, Student competition

**Type of presentation:** Poster

This study focuses on the analysis of theoretical and practical tasks from the International Biology Olympiad (IBO). The described research is the first step in a research project investigating students' cognitive, affective, strategic, and social development as part of their preparation for and participation in the IBO. Students' performance has been found to be strongly linked to their motivation. As studies revealed decreasing interest in science education across middle school, several approaches have been taken as counter-measures, ultimately aiming to increase the number of science majors. Extra-curricular learning opportunities like student competitions are one such measure. IBO's theoretical and practical exams aim to select the world's outstanding biology students. However, the construction criteria for these exams have been developed from experience over the last decades. To understand better what exactly the IBO exams assess and in how far this connects to current educational developments, the presented study categories IBO exam items. The employed categories are based on prior works on task analyses and focus on the items' underlying contents (domains, taxa, core ideas), science practices, cognitive processes, and language complexity. After categorization, the resulting data are used to determine how IBO tasks changed across the competition's history, as well as to determine factors predicting item difficulty. The findings are used to derive implications of how IBO exams might have to be adapted to connect well to educational requirements in schools and in students' future learning, as well to derive implications on how students can best prepare for IBO competitions. Additionally, the discussion of the results help to refine future research questions addressable with high-performing IBO students that allow it to draw conclusions for general biology education.

# **In search of a notion of biological competence for primary education: A review of research articles**

*Jairo Ortiz-Revilla, Ileana M. Greca and Agustín Adúriz-Bravo*

**Keywords:** Notion of competence, Scientific competence, Biology education, Primary Education, Systematic review

**Type of presentation:** Oral

The study of competence has now a 'history' in educational research, but debate persists around this controversial notion. In this presentation, we briefly discuss the origins and evolution of competence in science education, highlighting the contributions of two organisations (UNESCO and OECD) that were instrumental in the European rhetoric around competence. Afterwards, we present the methods and results of a systematic review on part of the available literature on competence in primary education. We focus on what the corpus that we selected says about scientific competence and on the references made therein to biology teaching. Results of our review show that research on the notion of scientific competence in primary education is scarce, and that explicit discussion of the specific contributions of biology to such competence is missing. This leads to the need of more theoretical production around the scope of what we call 'biological competence'.

# The plant species repertoire of basque secondary education students and their interest in nature

*Arritokieta Ortuzar-Iragorri, Iñaki Sanz-Azkue, Aritz Ruiz-Gonzalez and Joserra Díez*

**Keywords:** Biodiversity education, plant repertoire, secondary school students

**Type of Presentation:** Poster

Biodiversity has been acknowledged as a crucial issue at all educational levels and it has been proposed that students should be empowered to act towards biodiversity protection and conservation. However, in the last decades, children's knowledge and capacity to identify species of plants and animals has dramatically decreased. This is of special relevance taking into account that people might not care about unknown species and species they cannot name. To get further insights into this issue, 1040 secondary school students at the Basque Country (Spain), were asked to fill in a 10 plant species list and additionally, they were asked about their interest in nature, plants and animals. Most surveyed children showed interest in nature; only the 9% of the questioned reported little or very little interest on the issue. Also, as in many other countries, children in the Basque Country preferred to study animals or animals and plants rather than plants alone, which was the choice only for the 3%. Overall, 215 different plant species were mentioned, being the oak, the beech, the pine and the rose the most named. Each student listed 5.4 plants over 10. Out of those, 70% were autochthonous species. Students at the smallest surveyed village (720 inhabitants) were significantly the most successful at plant listing (listing on average 8.2 over 10 requested), and, among the listed plants, they also mentioned significantly more autochthonous species (83%). In general, wild and eatable species were mentioned with 10-20% more frequency than ornamental or wood producing. Additionally, arboreal species were more mentioned than herbaceous and shrub species. In order to improve knowledge on plant biodiversity, new lines of research and further emphasis on biodiversity and taxonomy in the teacher-training curriculum should be strengthened, together with innovative and effective biodiversity education materials at schools.

# **The practice of research-training-action, basic education curriculum and textbook, in a biological sciences degree**

*Maria Cristina Pansera-De-Araújo and Rúbia Emmel*

**Keywords:** Teaching Practice, Initial formation, Curriculum, Textbook.

**Type of presentation:** Poster

The research-training-action considers the contributions in the context of the curricular component Teaching Practice, in the Bachelor Degree Program in Biological Sciences, in studies on basic education curriculum and textbooks. The research's aim was to understand the constitutive character of the curriculum in relation to the textbook, according to undergraduate students of the Biological Sciences. The experience narratives they underwent were registered on the logbooks of fifty-four undergraduate's students; a full professor and a research professor. The role of the researcher-active teacher, in the component, made it possible to identify three reflective scenarios: 1) Relationships between Teachers and Students; 2) Trademarks and ties of the relationship between Professor, Textbook and Curriculum in the Biological Sciences degree; 3) Transformations of curriculum and textbook conceptions in "being a teacher"; 4) Critical discussion about the Textbook as an organizing tool for basic education classes. These scenarios allowed us to situate contexts in different themes and situations, which evidenced the need for initial training to discuss the theme, to constitute reflective teachers about the use of textbooks and authorship of the curriculum. The research-action and the narrative writing on the logbook allows us to connect theory and practice and assume a reflexive posture in a formative dynamic way for teaching in Biological Sciences. In some narratives, the teachers use the same sequences of textbook content, such as fungi and plants, without observing biodiversity near the school.

# Influence of Self-Efficacy and Motivation on Undergraduate Science Inquiry Practices

*Melanie Peffer and Emily Royse*

**Keywords:** authentic science inquiry, nature of science, science epistemology

**Type of presentation:** Oral

Nature of Science (NOS) understanding and beliefs about science knowledge, or science epistemology, are essential for attaining science literacy. Consequently, researchers and educators created several metrics to capture the NOS understanding and epistemological beliefs of children, teenagers, and adults. Although these metrics provided important insights, they are limited to the metric authors' philosophical assumptions and constrained by the static nature of pen and paper assessment, therefore only capturing a student's understanding at one point in time. To address these concerns, our previous work devised a novel method to assess NOS/science epistemology as situated in simulated authentic science inquiry, or Epistemology in Authentic Science Inquiry (EASI). We found that performance on a pre-test assessment of NOS/science epistemology predicted both practices within the simulation and the user's experience performing authentic science inquiry within the domain of biology. However, differences in practices and EASI could be explained by other factors such as motivation or self-efficacy. Here we report our preliminary findings on the influence of motivation and self-efficacy on practices in simulated authentic science inquiry within the domain of biology. Preliminary analysis compared correlations between students' motivation and self-efficacy and the actions they took within the simulation, namely how many times they sought outside information, how many tests they completed or hypotheses generated, and how long the students spent engaging with the problem presented by the simulation. Interestingly, high self-efficacy and low test-anxiety correlated with the number of information-seeking actions students took, while self-efficacy, task value, and intrinsic goal orientation related to how long students spent within the simulation. Although these findings are preliminary and limited to correlational relationships only, they may imply that different student beliefs about motivation may be able to account for some of the differences in inquiry practices. Future work will contextualize these results with in-depth analysis of their practices within the simulation, such as if the investigation focused on a simple cause and effect relationship or sought a sophisticated mechanistic explanation for the observed phenomena, and student performance on established metrics of NOS/science epistemology. This work will address potential confounding factors when interpreting EASI as seen through student practices in simulated inquiry and improve the quality and reliability of this assessment technique. Continued refinement of this assessment method will allow for future work within the biology classroom examining student EASI in real-time, allowing for better pedagogical intervention and improved science literacy.

# Investigating the Short- and Medium-term Effects of a School Kitchen-garden Project on Elementary School Students' Environmental Conceptions

*Stella Petrou and Konstantinos Korfiatis*

**Keywords:** Garden-Based Learning, School Kitchen-garden, Elementary School Students, Environmental Conceptions, Longitudinal Study

**Type of presentation:** Oral

At an early stage of life, students develop an understanding about natural world and there is a need for further research for nature of conceptions and constructions of "Environment" and other related terms because students' environmental conceptions may influence lifelong dispositions, attitudes and behavior. In this study, we tried to examine how students' involvement in school gardening influences their environmental conceptions in short- and medium-term. 41 elementary school students (8-9 years old) from two urban elementary schools, participate in the study. Participants were involved in the creation and cultivation of a kitchen-garden for period of approximately three months (April-June). Participants had the main role in the decision-making process and they also had the main responsibility for the cultivation of the garden. The project was managed by a common assembly formed by the participating children, their teacher and university researchers. Before the creation of the kitchen-garden, after the end of the growing season and the gathering of the crops and at the beginning of the next schoolyear, 41 participants were asked to list the first 5 words that came to their mind, for the stimulus terms "Environment", "Environmental Protection" and "Ecologist". After that, they were asked to create the "Environment" individually using miniatures. Based on our results, students' conceptions of "Environment" were dominated by the pure and romantic sense of nature while urban environments and the interactions human-nature were absent. Consequently, educators must give the opportunities to their students to enrich their conception of "Environment" through direct experience in various environments (e.g. urban/rural). Additionally, they enriched their conceptions of the terms "Environmental Protection" and "Ecologist", linking garden activities with the improvement of environment. However, there is a need to emphasize the importance of other types of environmental protection (e.g. political actions, legislation, social actions) through the environmental programs.

Our experience from this study suggests that elementary school students are quite flexible in enriching their environmental conceptions but the impact of kitchen-garden project on them was more obvious in short term as compared with medium term. Consequently, the long-term teaching interventions probably contribute to the more effective development of their environmental perceptions.

# **Understanding of evolution through natural selection in university freshmen: a comparison between students graduating from secondary education in Flanders, Belgium and the Netherlands.**

*Rianne Pinxten and Ellen Vandervieren*

**Keywords:** natural selection, Conceptual Inventory of Natural Selection, cross-national comparison, curriculum secondary education, university freshmen

**Type of presentation:** Oral

Secondary school teaching of evolution through natural selection is very important, because for many people, it is not only the first, but also the only, formal introduction to the scientific understanding of this unifying theory of biological science. It has been suggested that the specific treatment and place of evolution in the biology curriculum, may largely affect the level of understanding after completing secondary education. In Flanders, Belgium, evolution is taught only at the end of the last year of secondary education, as a separate and last chapter in the textbooks whereas in the Netherlands, evolution is already taught in the fourth year of secondary education and more integrated throughout the biology curriculum. The primary objective of this study was to describe and compare the conceptual understanding of natural selection in university students having their secondary education in Flanders or the Netherlands and subsequently enrolling in the first year of Biomedical Sciences or Veterinary Sciences at the university of Antwerp in Flanders, Belgium. By comparing students enrolling in the same program, we control for the potential confounding effects of different study interests and different fields of study attended in secondary education. We used a well-known questionnaire, 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 (KC), including four core concepts (CC), and the distribution and magnitude of misconceptions. A total of 389 first-year students participated, of which 98 had completed secondary education in the Netherlands. We used regression analysis to control for effects of other parameters besides country of secondary education. Dutch students obtained a significantly higher CINS-score (14.3 versus 12.2) and also scored significantly higher on all 4 CC and all but two KC. In addition, the proportion of Dutch students scoring at least 16/20 (=cut-off score for good understanding) was also significantly higher than the proportion of Flemish students (34% vs 19%). The final regression model revealed that country of secondary education indeed very highly significantly affected the CINS-score, in addition to age and two estimates of intellectual capability. The conceptual universe of alternative conceptions elicited by the CINS did not differ between both student populations. Taken into account that the tested students may be considered as the best possible performing secondary school graduates in both countries, their performance was nevertheless rather weak, implying that teaching of evolution in secondary education still needs improvement.

# Health and wellbeing – the school garden, a place to feel good

*Susan Pollin and Carolin Retzlaff-Fürst*

**Keywords:** health, wellbeing, school garden

**Type of presentation:** Oral

The school gardens may take over a significant function as an educational resource. Practical and theoretical work in a school garden lets the place become a relevant point of physical activity, stress reduction, sustainable learning and social interactions. With the task to investigate the possibilities of the teaching environment “school garden”, the research questions arise in terms of health education and personal skills. What effect of well-being and social-emotional competences has garden work on pupils of the sixth grade? The presence of nature can have positive effects on the well-being and social attitudes of humans. The first results of the Mood Questionnaire show a higher value of good mood and observations indicate more social interactions compared to school lessons in the classroom.

# **Biology students - future teachers' knowledge and attitudes towards migrations of species and diseases caused by insects**

*Katarzyna Potyrala, Malgorzata Klys and Karolina Czerwiec*

**Keywords:** insects, attitudes, teacher training

**Type of presentation:** Poster

The development of civilization and climate change caused an increase in the number and rate of migration of organisms (e.g. insects), which affect the changes of biodiversity and the functioning of communities, to which they are coming. Now, increasing migration of human population. Polish science and biology curricula contain issues such as: biodiversity, human diseases, meaning of insects in environment, microorganisms, but without correlations between particular problems, e.g. disease transmission by insects and migration of species. Therefore, the aim of research was to diagnose the knowledge and attitudes of the biology students - future teachers, on diseases caused by insects and relationship between migration of people and the spread of diseases.

It was assumed that biology students - future teachers: 1/ have a wide range of knowledge about diseases caused by insects and 2/ recognize that there is a correlation between the influx of migrants and the threat of the spread of infectious diseases, which were rare so far in European countries or have not been presented at all. Research was carried out with the use of diagnostic survey and the research tool - questionnaire (Thurstone scale).

Results of the research showed that 140 biology students-future teachers of the Pedagogical University of Krakow have a high level of knowledge in the field of infectious diseases (at the level of 62% to 92% depending on the issues about which they were asked). However, more of them (90% of respondents) express concern about outbreak of bacterial and viral diseases in connection with the possibility of uncontrolled human migrations. Such attitudes of biology students - future teachers can have an effect on the way of transformation of educational contents on migration of different populations and the interaction between them, which should be tested for deeper understanding of teaching contents.

# School students' engagement with contemporary biological research

*Stephen Price, Paul Davies, Haira Gandolfi and Ralph Levinson*

**Keywords:** Motor neuron pool formation, School student research, Model-making, hypothesizing

**Type of presentation:** Poster

School pupil perceptions of the nature of biological research are very far away from the reality experienced by practitioners. In an emerging climate of scepticism of “so-called experts”, an increased understanding of how knowledge is generated and the strengths and limitations of the evidence-based approach to biological knowledge is of great value. However, current teaching of “evidence” for biological processes is hampered by the rather mechanical descriptions of “hypothesis, experiment and conclusion” used to illustrate the scientific process in general. What this description misses is the insight, imagination and serendipity that characterises most real-world scientific endeavours, particularly in the Biological sciences where theory plays a much smaller role than in other sciences. This project seeks to engage with school students on a current biological research topic that they will not have been exposed to in their biology curriculum. It seeks to draw pupils into the nature of scientific investigation in biology through engaging their imagination in drawing on past knowledge to hypothesise a solution to the biological problem. Here, we find that student discussions illuminate the collaborative nature of biological research and engage the pupils in the requirement of the generations of testable models of investigation in solving contemporary biological research questions. Two aspects appear to be crucial: one is the ability to adapt school curriculum knowledge to other contexts using imaginative metaphors, the other is the social configuration of the group incorporating both openness and criticality.

# Perceptions of pre-service biology teachers about critical thinking

*Susanne Rafolt and Suzanne Kapelari*

**Keywords:** critical thinking, scepticism, suspiciousness, educational goals, domain-specific knowledge

**Type of presentation:** Poster

Critical thinking is a fundamental educational ideal and defined as a key competence for lifelong learning and scientific literacy. However, current societal development in Austria convey the impression that although research in science education has been discussing the role science education plays in supporting students to develop critical thinking for decades already, we hardly know anything about whether and how these ideas are put into practice. Thus we evaluated pre-service biology teachers' perceptions of critical thinking through a associative writing activity. Handwrites were transcribed and reviewed by using a literature derived category system in MAXQDA. Results show that most of the fifty-seven students feature a critical thinker with "putting something into question", but also with "being sceptical or suspicious". We argue that it is essential to give teachers and decision makers a clear and domain-specific explanation of the concept "critical thinking" before promoting it in classrooms, because faulty conceptions may misguide students to equate suspiciousness with the intellectually more demanding process of critical thinking.

# **Proposal of a Model for Professional Development: Perspectives and Stages that contribute to the improvement of the practice of teaching biology**

*Eduardo Ravanal Moreno and Édgar Valbuena Ussa*

**Keywords:** Professional development of teachers, Methodological strategy, Biology teacher

**Type of presentation:** Oral

Professional development is key to improve teachers' performance and the teaching of biology, therefore it is necessary to promote it and research all the ways that serve to achieve these aims, like testing the impact this development causes in the learning process of teachers and the consequences it has in the practice of teaching. As this is complex, we must find a way to begin; to this end a Model for Professional Development has been designed that centers on the biology teacher. The aim of this model is to help the participants to recognize, value and give new meaning to their professional knowledge, expanding the comprehension – based on those frameworks - of the way of teaching it promotes, which allows for better decision-making and an enhancement of the practice of teaching.

For this purpose a study of multiple methods was carried out which included the use of questionnaires, individual and group interviews, discussion groups and observation of biology classes. Analysis of the information led to the creation of a model for professional development that recognizes 4 stages in the learning process of teachers, which are: stage of professional Concern, Difficulties in Teaching, Practical Problems of Teaching and Formalization of Knowledge for Practice. Additionally, a methodological strategy was designed that implements the model procedurally and that we called RINDE con-Ciencia; this strategy was traced with 30 biology teachers working during different moments and in different work groups. Preliminary results indicate that the first way to access the thought processes of biology teachers is the stage of professional concerns. This stage has a lower level of complexity with regard to teaching, but it is at the same time an important scaffold for professional development which makes it possible to attain a greater clarification and problematization of teaching and the teacher's knowledge. The participants acknowledge the value of this model as a promoter of reflection, systematization of information and collaborative work. Thus, it constitutes a real opportunity for professional accompaniment to guarantee better teaching and learning results at schools.

# Teaching for less reductionism in biology education: students' views on the compatibility of science and religion

*Michael Reiss and Tamjid Mujtaba*

**Keywords:** science & religion, inclusive education, epistemic insight

**Type of presentation:** Oral

Recent years have seen increasing interest in the way that young people understand the relationship between science and religion. In England issues to do with religion are rarely considered in science lessons, partly because religious education is a separate, compulsory subject. However, the omission of any consideration of religion from school science lessons erects strict subject boundaries in a way that may suit many teachers but may frustrate or even mislead some students.

This paper examines data collected from a project, the aim of which was to see if biology might be taught in years 9 or 10 in ways that would be less reductionist. The lessons were taught in 2017. The particular research question we pose here is 'What are the characteristics of students who consider that science and religion are compatible?'

Before the lessons were taught, we developed an 'Attitudes to Science and Religion' survey. We piloted an initial version of this with 1085 students using a mixture of items from the existing literature (though many of these had not previously been validated) and items that we devised. After validation, a final version was completed by 1102 year 9/10 students across 18 schools.

One part of the survey looked at the extent to which students felt that science and religion were compatible. The construct consisted of six items. For each item, as on the rest of the survey, students responded by ticking one of six boxes from 'Strongly agree' to 'Strongly disagree'. The bullet points below show the correlation coefficients ( $r$ , and the significance values,  $p$ ) between a student's score on the construct that measures their view about the compatibility between science and religion and each of ten constructs (in descending order of correlation):

- Value of science to improve the world ( $r=.420$ ,  $p<.001$ )
- Value of science to society ( $r=.386$ ,  $p<.001$ )
- Awareness of environmental issues ( $r=.382$ ,  $p<.001$ )
- Critical thinking skills ( $r=.363$ ,  $p<.001$ )
- Extrinsic motivation ( $r=.329$ ,  $p<.001$ )
- Existence of God ( $r=.309$ ,  $p<.001$ )
- Interest in doing science ( $r=.295$ ,  $p<.001$ )
- Perception of science lessons ( $r=.300$ ,  $p<.001$ )
- Science self-concept ( $r=.291$ ,  $p<.001$ )
- Competitiveness ( $r=.244$ ,  $p<.001$ ).

It is noteworthy that it is the students who are less convinced about the compatibility of science and religion who are less positive about the contribution and worth of science.

# Emotions of Costa Rican Secondary students towards the development of a research project

*Diego Armando Retana-Alvarado, María Marta Camacho-Álvarez, Bartolomé Vázquez-Bernal and Andrés Osborne-Rovira*

**Keywords:** emotion, scientific thinking, research, secondary education

**Type of presentation:** Poster

The emotional factors such as interest, enjoyment and participation in the science of Secondary students are potential predictors of future interest in topics and activities of informal scientific education or the choice of higher education in science and technology. The purpose of this study is to describe the intensity of the emotions that Secondary students experienced towards the development of a research project in thematic areas such as Biology, Environmental Sciences, among others; to participate in Science and Technology Fairs. A non-probabilistic sample of 159 Secondary students, ages 13 to 18, from the 27 educational regions of Costa Rica, who participated as finalists of the National Science and Technology Fair in 2016, was formed. The participants answered a Likert scale questionnaire in which they expressed their degree of agreement on the intensity of seven positive emotions ( $\alpha=.85$ ) and seven negative emotions ( $\alpha=.82$ ) towards the development of the project. The data was subjected to descriptive analysis and exploratory factor analysis. The results indicate that, on average, positive emotions reached greater intensity than negative emotions. The factor analysis indicates a structure of three factors (Kaiser-Meyer-Olkin measure is ,813, significance is equivalent to ,000, variance for extracted factors reaches 60,4%, average variance extracted is ,53 and composite reliability equals ,94). The factors are determined by well-being, fear and rejection. Well-being correlates positively with all positive emotions. As the intensity of the tension increases, the intensity corresponding to fear, scare and frustration increases. Rejection is correlated positively with frustration, boredom and anger. The findings are relevant for European research in Biology Didactics because they allow the diagnosis of emotions in school research contexts, so the introduction of strategies of metacognition and emotional self-regulation could facilitate the reduction of the intensity of negative emotions, the development of scientific thinking skills and the increase of interest in science.

# Emotions of teachers in initial formation towards the teachers of Experimental Sciences Didactics according to gender

*Diego Armando Retana-Alvarado, María Ángeles De Las Heras-Pérez, Bartolomé Vázquez-Bernal and Roque Jiménez-Pérez*

**Keywords:** emotion, gender, emotional regulation, inquiry, initial teacher training.

**Type of presentation:** Poster

Several studies indicate that there are differences in the emotions experienced by teachers in initial training towards learning and teaching contents of Biology, Chemistry and Physics depending on the gender that influence future teaching. However, the influence of this variable on the emotions that they manifest with respect to the trainer is a line little explored in European research on Didactics of Biology. The present study compares in terms of gender, the intensity of the emotions experienced by teachers in initial training towards three biology professors of Experimental Sciences Didactics; before the inquiry of a socio-scientific problem about the construction of hotels in a Natural Park of Spain, a controversial situation with environmental, political, economic and social implications. There were 185 students (67 men and 118 women) of Didactics of Nature Sciences I of the Degree in Primary Education of the University of X in the academic year 2016-2017. The subjects answered a Likert scale questionnaire in which they declared their degree of agreement on seven positive emotions and seven negative emotions. The magnitude of the differences was estimated using the nonparametric Mann-Whitney U test, the calculation of the Type I and Type II error probability, the statistical power and the effect size. The positive emotions showed greater intensity compared to the negative ones. All negative emotions were experienced more intensely by males as opposed to females. Significant differences in tension, rejection, anger, boredom and frustration in favor of men. For their part, women showed the highest intensity in most positive emotions. Significant differences were established in well-being, interest, acceptance and enthusiasm for the benefit of the female group. These findings contributed to the reflection on probable causes that generated less affective proximity of men towards the teaching staff, in a subject in which the learning about the teaching of biological contents is addressed. At the same time, they allowed the incorporation of emotional self-regulation strategies as metaphors for the teacher and the creation of an adequate classroom climate in the design and application of the inquiry intervention that sought to make decisions based on evidence-based argumentation.

# Ideas about DNA age 9-14: from informal ideas to educational intervention

*Terry Russell and Linda McGuigan*

**Keywords:** Inheritance, DNA concept, Learning progression, curriculum

**Type of presentation:** Poster

Research was conducted in response to the introduction in 2013 of the new topics of evolution and inheritance to the science curriculum for primary pupils' (age 7-11) in England. In discussing inheritance, pupils revealed notions of kinship, but not causal mechanisms. Some revealed awareness of the relevance of DNA even though this concept is not introduced until several years later in the secondary curriculum. To explore the extent of out-of school knowledge of DNA derived from informal media across the primary-secondary transition years, an open questionnaire was administered to 298 pupils in the age range 9-14 years. In line with previous studies, sources of informal knowledge about DNA were found to be extensive. Pupils' views on the location of DNA, its function and more specifically, its role in human reproduction, were recorded and age-related trends identified. It was confirmed that some knowledge of the term and superficial aspects of technical applications had been gained – for example, in forensic contexts and in confirming family relationships. However, there was little awareness of the underlying science (e.g., the human genome project) prior to formal teaching in secondary school.

Educational intervention to enhance pupils' understanding of inheritance and the key role of DNA are reviewed in the light of the evidence. In addition to pupils' life world experiences, novel curricular requirements for Computing and for Personal, Social, Health and Economic (PSHE) education have been introduced. Extra-curricular awareness of computer software programming has been reinforced by the mandatory Computing curriculum, potentially strengthening receptivity the metaphor of DNA as a code. Furthermore, 'relationships and sex education' within PSHE, (likely to be mandatory from 2019), offers opportunities for exploring the understanding of mechanisms of inheritance and the function of DNA. Rather than view informal ideas as misconceptions to be eradicated, erroneous though they often are, it is argued that educational interventions are better thought of within the framework of developmental learning progressions. Within such an overarching perspective, the roles of metaphors, simulations, narrative, concrete modelling and confronting misconceptions are considered. This broad strategy addresses fragmentary and disconnected ideas in pursuit of continuity and progression. The conclusion is drawn that an approach that favours defining a developmental learning progression from late primary to early secondary education is feasible. Late primary to secondary transition is suggested to be an appropriate time to introduce the currently missing core concepts of the cell, controlling nucleus and cell division.

# Drawings on biology. How can drawings help to conceptualize flowers?

*Eliza Rybska and Jelle Boeve-De Pauw*

**Keywords:** drawings, cognitive imagery, flowers, children conception, conceptualization

**Type of presentation:** Poster

Drawings are very interesting tool not only in educational process but also in science education. In presented paper we would like to show the implementation of a model of using drawings in a process of conceptualization of a flower. This model includes three aspects of graphical representations that are: scheme (as observational drawings), drawings (as learner-generated drawing) and scheme (as designing or problem solving through drawing activity). We have shown in our research that the concept of a flower is very twinkling, but during planned intervention a conceptualization that involved cognitive imagery shows good and promising results.

# How to make evolution an operational concept to understand the world: learning with Darwin.

*Xana Sá-Pinto, Alexandre Pinto and Joaquim Bernardino Lopes*

**Keywords:** Evolution education, History of Science, Elementary schools, Conceptual articulation

**Type of presentation:** Oral

Evolution is a core concept in biology that is essential for people to understand the surrounding world, to tackle personal and societal problems and to make informed decisions with implications to the entire society. Given its importance, evolution has recently been considered one of the four concepts in biology that should be explored across the entire students' academic course since kindergarten. But few information is available about effective strategies to teach evolution at such young ages. What concepts and conceptual connections can trigger understanding of natural selection? And how can these be explored by elementary school students? Among other important roles in science education, science history may help us to identify processes and contexts that lead to important scientific discoveries and which may inform the design of educational programs and activities. In the present work, we identify the concepts and conceptual connections that were fundamental for Charles Darwin to discover the process of natural selection and look if and how these concepts and connections are present in portuguese elementary school curricula. With this, we aim to contribute to identify educational opportunities to foster evolution understanding in elementary schools.

# Teaching & learning laboratories in biology teacher education: Analysis of students' reflections on teaching experiences

*Antje Saathoff and Corinna Hößle*

**Keywords:** teaching & learning laboratories, biology teacher education, reflective teaching, group discussions

**Type of presentation:** Oral

One possibility to integrate more practical parts into biology teacher education is the implementation of teaching & learning laboratories. In addition to the pupils' learning process, the focus lays heavily on students' teaching. Therefore, students are given the opportunity to plan and then repeatedly test, reflect, and optimize a biology teaching sequence in the context of teaching & learning laboratories and the accompanying seminars. This is done in order to expand their pedagogical content knowledge (Hößle, 2014). In this case, the step of reflection is a basis for an increase in competence and proficiency. In current discourses of educational research, reflection is classified as a key competence for professional teacher action (Combe & Kolbe, 2008). In addition, the German Standing Conference of Education Ministers also notes that the reflection of teaching experiences in extracurricular places of learning is a possibility to develop these competencies (KMK, 2004). The main objective of this study, thus, is to analyze how pre-service biology teachers reflect on their own teaching experiences in a teaching & learning laboratory.

For this explorative study, we used a qualitative case study design. In order to collect data, students' reflections (N = 14) were recorded as part of the seminars. Additionally, group discussions (N = 10) were conducted, within which students were able to reflect on their own teaching experiences. The sample includes pre-service biology teachers in their bachelor- (N = 29) and master- (N = 43) degree. All data are analyzed using the qualitative content analysis according to Mayring (2015). Various approaches to teaching reflections can be derived from case-by-case analyses. These provide insights into difficulties that students may have during reflection. For some students, for example, it is difficult to grasp responsibility for their own teaching. Instead, external factors are often referred to as the causes of difficulties encountered and students rarely reference their own teaching activities. From these results, implications are discussed in order to optimize the use of teaching & learning laboratories in biology teacher education and the chances for the professional development of students.

# How do pre-service teachers address tree and bush identification?

*María José Sáez Bondía and Ángel Luis Cortés Gracia*

**Keywords:** Fieldwork, plants identification, pre-service teachers, learning process

**Type of presentation:** Poster

This paper is part of a larger set of case studies involving pre-service primary and secondary teachers. Making field trips to nearby natural environments is a strategy for students to learn how to identify plant specimens. Knowing some nearby plant species is a first step towards understanding more complex concepts, such as those related to ecology and the environment. We focus our study on how a group of pre-service primary teachers addresses the identification of plant specimens during a practical activity. This proposal was structured into three tasks: 1) before the field trip, the students were instructed on theoretical aspects of plants and also on the assignment in the field (university gardens); 2) during the field trip, the students collated data on the characteristics of the specimens they observed with the help of an observation guide; 3) after the field trip, using specialised books and the data collected in the gardens, the students finally identified specimens and they wrote about the entire process in a report. The entire process was video recorded to analyse the sequence of strategies the students performed during the activity. The complete transcription of the recorded files, including the moments the group of students encountered a difficulty and the sequence of strategies they used to solve it, was analysed considering the stages of inquiry. Results suggest the decisions taken to solve difficulties barely extend beyond an explanation linked to the data students collate. Most of the identified sequences are linear (quick and 'easy to solve' for them) whereas complex sequences (cyclic) usually emerge when a teacher appears.

# **A role-change approach in biology pre-service-teacher education at an outreach lab: a direct replication study adding a new focus on module-phase-dependent development of pedagogical content knowledge**

*Franz-Josef Scharfenberg and Franz X. Bogner*

**Keywords:** Biology teacher education, pre-service teacher education, pedagogical content knowledge, outreach education

**Type of presentation:** Oral

How pre-service teachers (PST) may develop components of their pedagogical content knowledge (PCK) during teacher education is an open research question. Theoretically based on PCK, we have implemented an innovative role-change approach in our Teaching-and-Learning-Outreach-Lab, combining PST (master graduation) and student education. After a theoretical and a practical preparation, the PSTs hereby change their role during three subsequent days with identical student module's content, but daily changing student groups: from a student role on the first outreach day, to a tutor role on the second day, to a teacher role on the third day. In a previous study (Authors, 2016), we have shown that, as components of their PCK, our role-change approach changed the PSTs' orientations toward teaching biology to a more student-centered orientation and in how they addressed potential student learning difficulties (SLDs) and identified potential instructional strategies for avoiding these SLDs. In order to focus on potential effects along the module phases in detail, we replicated our study, but added four more module-phase-dependent test dates. Altogether, 72 PSTs and 82 student classes (N = 1413) participated on our study. Again, we administered pre- and delayed posttests in order to monitor these specific PCK components. Additionally, we captured the PSTs' views on potential SLDs, after lab preparation and after each role being experienced. We content-analytically categorized all the qualitative data (N = 2066 PST statements; ten categories, e.g., equipment-related SLDs) and quantitatively analyzed their frequencies. Finally, we cluster-analytically compared the individual PST views on potential SLDs.

First, we directly replicated all our first-study results. Second, starting with similar SLD views, the PSTs changed their views dependent on the experienced module phases (Pearson's C: .257 to .458;  $p < .001$ ). Third, we extracted three PST clusters based on their SLD views: overall-oriented (seeing both hands- and minds-on related SLDs), hands-on-oriented and minds-on-oriented SLD view types whose members did not differ till experiencing the tutor role. Fourth, only overall-oriented PSTs changed their orientations toward teaching biology to a more student-centered orientation. Our results point to the adequacy of our role-change approach in PST education, especially the tutor role, and support a "step-by-step" PCK development, "constantly refined on the basis of individual experience" (Bindernagel & Eilks, 2009; p. 78).

# **MultiCO: Promoting students' interest and their awareness of science careers**

*Annette Scheersoi, Jonathan Hense and Lara Weiser*

**Keywords:** Interest in science, science careers, stakeholder cooperation, stereotypes

**Type of presentation:** Poster

The H2020 EU-Project MultiCO undertakes research on an approach to science education, that is designed to raise the students' interest in science, by focusing on making school science more relevant and exciting for students, as well as raising their awareness of the multitude of science-related careers. This project examines the impact of the introduction of real-life related, career-focused stories ("scenarios"), which initiate context- and inquiry-based science lessons. In five countries, the students' (N = 1032) interest development is studied.

In one of the biology lessons, for example, an intervention focused on the subject of "The forest as an ecosystem" and presented the forest engineer profession. At the beginning of the intervention, the students (14 years old) were asked to draw a forester, in order to encourage them to think about their image of this profession. The students were then taken to the forest to meet a real forester (forest engineer and his colleagues). Together with the experts, the students then carried out investigations that are typical for this professional field (e.g. the determination of soil organisms, the survey of trees and the exploration of a soil profile). Back in school, the students again drew a forester and discussed their experiences.

At the outset, the students had a relatively stereotypical image of the forester profession (old man with a dog and a rifle). This changed through the encounter with people who work in this professional field. In that way, the students discovered that foresters work in a large range of activities and that women are also represented in these professions. The students especially liked the practical work in the forest and the use of authentic tools/equipment. They appreciated the new experience and the visualization of biological content that they had dealt with before, in theory in the classroom.

The project's research focuses on producing evidence of the impact of such interventions on students' interest and science study choices, attitudes towards science-related careers, and tangible outcomes for use by researchers, teachers, teacher educators and policy-makers for future educational planning.

# **Learning about evolution along a learning progression - a longterm case-study**

*Jaqueline Scheibstock, Heidemarie Amon and Martin Scheuch*

**Keywords:** students' conceptions, Evolution, longitudinal study, learning progression

**Type of presentation:** Poster

Various studies have pointed out specific students' conceptions which hinder students from understanding evolution. However, long-term studies about the development of these conceptions along a research based learning progression are still missing. To fill this gap, this study documents the conceptual reconstruction along a learning progression of three students over several years. During this period these students attended novel teaching and learning sequences about evolution organized in a learning progression which is based on students' conceptions. The evaluation of these sequences is an additional goal of this study.

Designed as a longitudinal study following the case study approach, data was collected via pre- and post-interviews as well as additional observations of the lessons. The students' conceptual understanding of fundamental evolutionary concepts is reconstructed through qualitative content analysis. Their concepts of central evolutionary phenomena develop from everyday conceptions to more scientific ones through the theory based teaching and learning sequences. This study investigates the conceptual reconstruction of three students due to a research based learning progression and contributes to the research field by focusing on how students build up and broaden their personal conceptions over the years. Furthermore, it reveals the benefits of biology lessons which, on the one hand, focus on students' conceptions and, on the other hand, are organised in a learning progression.

# Students' conceptions about the urban water-cycle

*Sarah Schmid and Franz X. Bogner*

**Keywords:** Misconceptions, alternative conceptions, water, environmental scientific literacy

**Type of presentation:** Poster

The concepts of 340 university freshmen concerning the urban water-cycle were analyzed regarding misconceptions (scientifically in-correct). The study revealed that Germany's highest educated school graduates hold conceptions that partly differ from reality. Only few students knew the correct urban water-cycle: consumer (given), sewage-plant, nature and water-works. The cycle steps "nature" and "water-works" are mainly missing. The importance of the "sewage plant" seems to be exaggerated when the topic is taught. School and media were main sources of information for freshmen. We conclude that everyday topics with such an important impact to our life-standards need to be focused more during school time. The only focus on the urban water-cycle currently is made in primary school. As our study shows, this singular teaching slot seems to be not enough to build up long lasting knowledge that can be retrieved correctly as a young adult. However, the study revealed as well, that school is the most important source of information concerning wastewater and drinking-water, therefore chances are good alternative conceptions may be reduced through school education.

# Motivation of Newly Arrived Students in the Science Classroom – “If one wants to become a doctor he has to study Biology.”

*Mario Schmiedebach and Claas Wegner*

**Keywords:** CLIL, motivation, science education, action-orientation, newly arrived students

**Type of presentation:** Oral

In the last years, the number of children entering the German school system hardly speaking any German has increased tremendously due to the increasing process of migration and fleeing. In order to foster language acquisition and facilitate the integration into the regular school system, these students are often enrolled in so-called “international classes” before being fully integrated into the German school system. Depending on the school, usually these classes have mainly German lessons and rarely any other subjects.

In order to cope in the regular classroom eventually, the students need to be educated in other subjects as well. In the project “Biology for Everyone”, students of two “international classes” are taught in science. The science classroom is action-oriented and the students can understand scientific content through hands-on-experiments while improving their German simultaneously by expressing observations. The students create a new linguistic register which will help them to cope in the regular science classroom. The concomitant research examines the students’ motivation concerning the science classroom and their second language acquisition as well. So far 30 guideline-based interviews with 18 participants have been conducted and are being analyzed according to qualitative content analysis. First results show that the students perceive the lessons as a chance for integration due to studying relevant content and the improvement of their German concerning specific language structures needed for science which will help them to participate in the regular science classroom. Furthermore, students talk about personal factors influencing their motivation such as the desire to become a doctor or the interest in specific topics such as working with animals. In conclusion one can say that the students value the integration of content and language learning in general but especially the structure of the science classroom with the hands-on approach seems to be a reasonable concept for learning new content for this group of students.

# Students' attitudes towards biodiversity conservation

*Jennifer Schneiderhan and Franz X. Bogner*

**Keywords:** environmental education, education for sustainable development, students' perceptions, attitudes, cognitive learning, biodiversity

**Type of presentation:** Poster

Biodiversity loss is one of the major threats of our time. This man-made crisis requires a society which is aware of the concept and value of biodiversity. In order to enable students to become responsible citizens, the issue as such must be a key element of education for sustainable development. Since little is known about students' perceptions on biodiversity we developed a student-centered, inquiry-based learning module, using the forest as an example of an ecosystem, where diversity is endangered by anthropogenic activities. We paid special attention on raising awareness for the value of the ecosystem and a sustainable utilization. The overall aim of our study, which is still in progress, is to investigate the impact of our three hour biodiversity education module on students' knowledge, attitudes and values.

# Interacting with Digital Touch Tables to Explore the Biological Microcosmos

*Konrad Schönborn, Gunnar Höst, Henry Fröcklin and Lena Tibell*

**Keywords:** visualization in biology education, (sub)microscopic scale, interactive educational technology, touch table interfaces, science centers

**Type of presentation:** Oral

The digital revolution provides new ways for communicating science. Hands-on interactive exploration in digital science center contexts could provide opportunities for learning about phenomena beyond our direct human experience. Modern interactive technologies are relevant for scientific meaning-making, and tools that log users' behavioural interactions offer a fine-grained window into how interaction processes could relate to engagement and learning. Development of the Microcosmos multi-touch interactive table at the [anon.] science center, provides visitors with possibilities to view and manipulate embedded visualizations of (sub)microscopic biological structures and processes. This paper presents the integration of biological content, interactive features and logging capabilities into the Microcosmos table interface, and provides an analysis of visitors' patterns of interaction with the visualized biological content. Sixty-four image "cards" (43 static and 21 dynamic) across seven categories (proteins, viruses, cells, molecules, genes, processes of life and diseases) were embedded in the table. Interaction with a card(s) is through finger-based gestures that include, for example, selecting and moving a card with a single finger, and zooming or rotating a card with two fingers. Center visitors explored the table freely from 1-9 July 2017. Integrated logging recorded 662470 time-stamped events including activated category, selected card, as well as card and finger coordinates related to movement, rotation and zooming. Analysis revealed that visitors interacted with all 64 cards during 251 sessions. The average session time (an interaction period separated by at least 60 seconds of inactivity) was 115 seconds. Finger movements covered an average accumulated distance of 4.8 meters per session, and >60% of interactions were performed using two fingers. The most and least frequently activated category was viruses (266 activations) and proteins (186), respectively. All except one of the five most preferred cards concerned viruses, and three were microscopy images (e.g. a blood vessel cross-section). None of the five least used cards concerned viruses or micrographs, and communicated cellular processes stylistically (e.g. a representation of membrane transport). In conclusion, visitors' average session times correlate with reported exhibit interaction times in science center contexts. The large finger traversal distance and high proportion of two-finger interaction may indicate the intuitiveness of the gestures, and the relevance of bodily interaction in content exploration. Visitors favoured cards about viruses, and preferred "realistic" rather than "stylised" visual content. Future research will use these trends to investigate the role of embedded science narratives as an additional pedagogical tool for communicating biological phenomena in interactive table interfaces.

# The potential of using digital tools in an environmental education context to address pollinator conservation issues

*Mona Schönfelder and Franz X. Bogner*

**Keywords:** eLearning, environmental attitudes, environmental education, perception, situational emotions

**Type of presentation:** Oral

Pollination is an essential process in terrestrial ecosystems. However, pollinating insects are affected by the current loss of biodiversity on a global level. One possibility to raise awareness for pollinator conservation on a local level is education. Unfortunately, pollinating insects such as bees are often perceived as frightening animals which may hinder successful learning processes. Thus, any educational initiative must conquer this obstacle and promote positive perceptions as well as conservational knowledge. Living animals, especially flying insects such as honeybees, are often difficult to handle in everyday school life which requires alternative methods and approaches. Using a quasi-experimental design, we evaluated the effectiveness of an educational setting using an eLearning approach. Almost 200 secondary school students participated in our programme using HOBOS as digital tool, a learning platform that is connected to a remote beehive. We monitored students' environmentally relevant knowledge of bees, their environmental attitudes, their perception of bees as well as students' situational emotions during the programme. The results indicate that our approach leads to the acquisition of conservational knowledge in the short- and long-term as well as to an increase of positive perceptions of bees in regard to perceived danger, interest and the willingness to protect bees. Direct experiences with nature are regarded as crucial, but using an eLearning tool in environmental education constitutes an outstanding alternative. While all students' situational emotions could be held on a high level, adolescents with low 'green' attitudes responded positively to the online beehive.

# **The effects of teacher self-efficacy and experienced Biology lessons as a student at school on prospective teachers' beliefs about teaching and learning Biology**

*Fabian Schumacher, Melanie Basten and Matthias Wilde*

**Keywords:** constructivism, prospective teacher, teacher beliefs, teacher self-efficacy

**Type of presentation:** Oral

Teacher beliefs about learning and teaching constitute a part of teachers' professional competence in teaching Biology. They have a great impact on teachers' construction of learning environments. Prospective teachers do not start their teacher-training without pre-assumptions about learning and teaching. Knowing the origin of these beliefs is important to optimize Biology teacher-training in universities. One possible cause are the lessons experienced as a student at school. Biology classes especially offer the opportunity for applying the didactic principle of constructivism. Teachers' perceived self-efficacy has an effect on creating constructivist learning environments. Teachers with a high level of self-efficacy tend to have higher levels of constructivist teacher beliefs and provide more student-centered and open learning environments. The aim of this study is to investigate the relationship between teacher self-efficacy, the experienced Biology lessons as a student at school and prospective teachers' beliefs about teaching and learning Biology.

233 prospective Biology teachers from Germany (Mage=21,58±3,5; 76,8 % female; Msemester=3,03±3,3) participated in our correlative study. The undergraduate students' perception of how constructivist their last experienced Biology lessons were, their perceived self-efficacy and their beliefs about teaching and learning Biology were assessed during university lectures.

We found significant differences in the constructivist teacher beliefs about teaching and learning Biology when comparing students who experienced their last Biology lessons more constructivist and students who experienced the lessons less constructivist. Prospective teachers who experienced a more constructivist Biology education reported higher constructivist teacher beliefs than prospective teachers who experienced their Biology education as less constructivist. Furthermore, students with a stronger perceived self-efficacy expressed higher constructivist teacher beliefs. There was also a significant interaction of the effects of constructivist Biology lessons at school and teacher self-efficacy on constructivist teacher beliefs. Teacher self-efficacy had a more positive effect on constructivist beliefs for students with less constructivist experiences at school. The results of this study indicate an influence of the lessons as a student at school on teacher students' beliefs about teaching and learning. Biology lessons perceived as constructivist promote the development of constructivist teacher beliefs. A strong self-efficacy has an impact on the present constructivist teacher beliefs, as well. Student teachers with a strong teaching efficacy tend to find open learning environments and student activity important for their Biology learning. University didactics should therefore pay attention to teacher students' experiences at school and develop their self-efficacy in order to qualify them for constructivist Biology teaching.

# Regenerating our place: Fostering a sense of place through rehabilitation and place-based education

*Wisam Sedawi, Orit Ben Zvi- Assraf and Michael Reiss*

**Keywords:** Place-based education, Sense of place, Elementary school

**Type of presentation:** Oral

The study presented here examines the effects of a place-based intervention unit designed to promote environmental sustainability in the context of place and community. Its goal is to determine how place-based education influences sense-of-place in the Hebron Stream area among elementary school students in the Negev's Bedouin Arab community.

The polluted Hebron Stream has become a real environmental hazard to the local population living nearby. Reclaiming it will require the cooperation of all the organizations and authorities located on its route, as well as the active involvement of local population. This study follows groups of fifth-graders (n=107) as they go through a two-year place-based learning program in the Hebron Stream area. The intervention program's purpose is to help the students develop an in-depth understanding of authentic environmental phenomena in the stream's surroundings, while fostering their sense of attachment to the stream. The program employs both indoor and outdoor learning, located either at Hebron Stream or at other streams, to see what a 'healthy' ecological system looks like.

Methodologically, data were gathered, both before and after the intervention, via drawings and individual interviews. The students were asked to draw two pictures – "my village" and "the stream in my environment" – and to explain their drawings in the interview.

The findings show that after the intervention, the Hebron Stream became part of the students' sense of place. Overall, the students drew a cleaner, more aesthetically pleasing stream, and about a third drew a model of the stream as a 'healthy' ecological system. The students' explanations show a rise in their awareness of the stream's importance as a natural resource, as well as an increased awareness of the need for cleanliness in their village, and of the presence of trash bins in their environment.

The results of this research support the idea that place-based science education can help develop students' sense-of-place. The long-term intervention program included direct experiences that helped develop the students' appreciation for the stream as a natural resource, and fostered their desire to protect it. Finally, the intervention showed that sense-of-place is also influenced by the economic and political factors that affect a place's physical condition.

# Analysis of the results of the university entrants' tests in biology

*Helin Semilarski, Anne Laius and Uko Viisut*

**Keywords:** entrance test in biology, core disciplinary ideas in biology, achievement profiles of future medicine students

**Type of presentation:** Poster

One of the main problems in biology education is the need to know which topics in the biological body of knowledge are not understandable to students and which impede them to get good results in entrance exams to medical faculty of university. The aim of the current study is to gain an overview of biological knowledge of students, who are intending to continue their education in the faculty of medicine after the end of their gymnasium studies and what are the crucial topics in which they under-achieve. Based on these results, it is expected to be able to make theoretically justified decisions about the core ideas of biology should be taught in school biology and how to develop the school biology curriculum in order to meet the needs, both of competence- and knowledge-based biology education. Three years' (2015 – 2017) medicine faculty entrance tests of biology were analysed, taken by 544 student candidates. The questions of the tests were categorized into 4 different disciplinary topics, based on 4 core ideas of biology according to the new Generation Biology Standards: structures and processes; ecosystems; heredity and biological evolution, which are also included into the Estonian National Curriculum as main topics. Research data was collected by means of three biology subject tests, which were composed of 50-item multiple-choice questions. The exam results enabled to detect four different achievement profiles of students according to their answers within four disciplinary core topics of biology. In all three years of this study, the distribution of students' exam scores were in correspondence with normal distribution and were in accordance with the Estonian National Curriculum assessment regulation system, with 15% of gymnasium graduate students achieving the highest score level and being successful in entrance to the faculty of medicine.

# **An analysis of seventh grade students' mental models concerning climate change**

*Vanessa Sesto and Isabel García-Rodeja*

**Keywords:** Mental models, Climate change, Greenhouse effect

**Type of presentation:** Oral

There are several studies dealing with students' ideas on climate change, but most of them refer to the understanding before instruction. Therefore, this study represents a new contribution to the area of Environmental Education, since its main purpose is to describe the levels of sophistication of students' mental models on climate change before and after instruction. The participants were forty seventh grade students in Spain who received specific instruction about climate change. As a method for data collection, it was used an open-ended questionnaire focused on the mechanism, causes and actions to slow down climate change. The participants individually covered the same questionnaire before (pre-test) and after (post-test) instruction. As a method for data collection, students' mental models were identified through an inductive and iterative analysis of their written answers. In a first analysis, categories were inferred describing the key ideas to which students mentioned in their answers. In a second analysis, each questionnaire was analyzed globally, incorporating students' ideas in broader constructs, known as mental models. The results show that the participants' mental models can be grouped together into four levels of sophistication that reflect a progression in students' understanding of climate change and the greenhouse effect. The Level 1 groups descriptive models in which no operating mechanisms are shown. It is considered the lowest level of sophistication. The Level 2 grouped together models including the idea that pollution causes ozone depletion or formation that allows more sun's rays to reach the Earth. The Level 3 grouped together models including the idea that there are greenhouse gases in the atmosphere that trap the sun's rays. The Level 4 groups the models closest to the model of school science. We can conclude that students with models in Level 1 tend to modify them towards more sophisticated models. Students with models in Level 2 tend to remain on the same level despite receiving specific instruction. This change is unlike to occur because these models are extremely functional for students, allowing them to explain the mechanism, causes and consequences of climate change. As educational implications, we insist on the need to give students opportunities to make their models explicit and to confront them with the models of school science.

# **Decision Making Considerations of Israeli Religious Undergraduate Students in the Field of Genetic Testing and Genetic Counseling.**

*Merav Siani and Orit Ben-Zvi Assaraf*

**Keywords:** Qualitative analysis, semi- structured interviews, decision making, genetic testing, genetic counseling, religión, genetic knowledge

**Type of presentation:** Oral

The study presented here examined the decision making concerns of Israeli religious undergraduate students, some of whom study life sciences (LS) and some of whom do not, and the considerations they take into account when faced with the need to have genetic testing or attend a genetic counseling session. Qualitative data was collected from 51 semi-structured interviews with students, in which recurring themes were identified using 'thematic analysis.' The codes from the thematic analysis were obtained according to 'grounded theory'.

Our results show that religious undergraduate students' decision making in these issues is influenced by their former genetic knowledge. The genetic decision making of students who do not study life sciences was characterized by fear and stress. They expressed ambivalence regarding having an abortion, and argued against interference in God's creation more than the LS students. Nevertheless, LS students did not define themselves as less religious, and faith was still part of their decision making considerations, though to a lesser extent than amongst students who do not study LS. The major conclusion from this research is that genetic knowledge is an important factor affecting decision making in the field of genetics among religious students. Moreover, studying sciences exposes the learners to scientific knowledge, expanding their scope and enabling them to accept the scientific system.

# Teacher assessment, grading and feedback: biology laboratory work in Slovenian secondary school

*Andrej Šorgo and Urška Cigler*

**Keywords:** Teacher assessment grading and feedback, biology laboratory work, Slovenia, secondary school

**Type of presentation:** Poster

**Background.** Laboratory and experimental work are among the keystones in teaching Biology, allowing achievement of manipulative skills, while affecting attitudes toward Biology, in addition to affecting cognitive learning outcomes. Students like such work, recognize it as motivational and would like to experience it more often. From previous studies, we know that Slovenian Biology teachers' preferred style comprises guided laboratories with well-defined outcomes at the cost of inquiry- and problem-based ones. However, we had little information about the assessment and grading of biological laboratory work in the Slovenian context.

**Aim.** The purpose of this study was to gain insight into the assessment and grading of laboratory work in secondary school Biology.

**Methodology.** The research method was a survey with a self-reporting questionnaire as an instrument for assessment of the type and frequency of assessment and grading of biological laboratory work performed in secondary schools. The sample consisted of 185 first-year university students, who retrospectively answered about their experiences in secondary school.

**Results.** 32% of respondents reported that the content of laboratory work was never graded, and the others that it was graded as tasks included in regular written or oral grading. Regarding reports on laboratory work, 34% of respondents reported that they had received a summative grade; 29% said that their work was never graded, and only 16% reported that each lab exercise was graded separately. When considering the different components of laboratory work, often it was only the summative end-reports that were assessed, and the most neglected component was grading of the student's readiness for lab work. Students received feedback mostly as a group class activity; however, correction of individual reports was much rarer.

**Conclusions.** The combination of "cook book" laboratories, without the necessary feedback is a lethal combination for the achievement of 21st century skills.

**Recommendations.** The findings call for additional education for teachers and provision of easy-to-follow guidelines for assessment and grading of lab work.

# Knowledge of the concepts of pollination and bee pollinators by biology students

*Jelena Stanisavljević and Ljubiša Stanisavljević*

**Keywords:** Pollination, bee pollinators, pollinator declines, knowledge, biology students

**Type of presentation:** Poster

Knowledge of the concepts of pollination and pollinators is extremely important in understanding the basic biological and ecological principles. Majority of animal pollinators important to agriculture are insects, of which the best known are bees (honeybees, bumblebees, stingless bees and solitary bees) (Kevan, 2007). Pollinator communities may be changed, because of global change (e.g. climate, land-use intensification and farming system). Today, there is a risk for food production which arises from a loss of diversity of pollinators. Considering that students should know the concepts of pollination and pollinators, it is essential to bring these scientific concepts closer to their current understanding.

Based on the above, we started verifying students' knowledge of concepts of pollination and bee pollinators in Faculty of Biology. The aim of this research was to determine which aspects of pollination students know and do they understand the role of bees (especially solitary bees) in pollination. A key objective was to determine whether the students know the factors of pollinator declines. The research included the total of 70 students who completed the second semester at the Faculty of Biology. As a research instrument, a questionnaire was used. The data were analyzed and results were obtained by using standard Chi-square ( $\chi^2$ ) test and one-way analysis of variance (ANOVA). Based on the results, it was concluded that vast majority of students who participated in this research know the definition of pollination and that the bees are the most effective pollinators among insects. It was shown that the structure of the honeybee colony and the importance of bee pollinators in terms of food production are familiar to them. But they don't know the difference in pollination efficiency between honeybees and solitary bees and the differences in structure of colonies among bee pollinators. Most of the students didn't recognize the importance of modern agriculture and climate change as factors of pollinator declines. Also, the correlation between knowledge of pollination and bee pollinators with an average grade in the studies is determined. Considering the above-mentioned results, the implementation of additional university programme content related to solitary bees and pollinator declines in the teaching subjects within the entomological framework is planned.

# Can prompt-cards support students' self-efficacy regarding experimentation and their quality of motivation during experimentation in biology lessons?

*Cornelia Stiller, Alexandra Stimmmler and Matthias Wilde*

**Keywords:** Prompts, Experimentation, Self-efficacy, Intrinsic Motivation

**Type of presentation:** Oral

Experimentation can be perceived as very complex (Harlen, 1999). Complex learning environments and high degrees of autonomy could lead to high cognitive demands. Consequently, students should be supported by instructional guidance (Mayer, 2004). Full-structured inquiry processes often do not focus on understanding experimentation (Hofstein & Lunetta, 2004). They might be inappropriate to promote students' critical scientific reasoning skills (Sadeh & Zion, 2012). A combination of instructional support and open inquiry is needed (Mayer, 2004). Prompts give instructional guidance during experimentation by offering hints. Furthermore, using prompts as an option allows students to work on a task autonomously (Ge & Land, 2003). If students can choose about an adequate degree of structure, the tasks may correspond with the students' skills and consequently increase their perceived competence. Perceived autonomy and perceived competence are regarded as predictors for intrinsic motivation (Deci & Ryan, 2000). If students perceive themselves as competent, their self-efficacy can be fostered as well. Furthermore, studies showed that feelings of self-efficacy influence intrinsic motivation (Bong & Skaalvik, 2003). The aim of this pilot study was to examine whether the use of prompt-cards has an effect on students' experimental self-efficacy and on students' motivation in comparison to full-structured experiments in a cookbook style. In this study, four six-grade classes (N=103) of a German secondary school participated in a teaching unit dealing with the behaviour of isopods. The classes were randomly assigned to two conditions. The 'full-structured group' (n=52) worked with full-structured experimentation guides. The 'prompt-card group' (n=51) received prompt-cards as supporting material during experimentation. Both groups differed in the instructional support during the steps of planning and analysing an experiment. During experimentation, the students in the 'prompt-card group' documented to which extent they used the 14 prompt-cards. The analysis of the extent to which the prompt-cards were used showed that these were rarely used. The results of the ANCOVAs showed that the students did not benefit from prompt-cards in their experimental self-efficacy and their motivation, respectively. Students of the 'full-structured group' perceived themselves as significantly more competent in planning, conducting as well as analysing the experiment and were more intrinsically motivated than students of the 'prompt-card group', after controlling for the effect of the covariates (general experimental self-efficacy, Relative Autonomy Index). Possibly, students needed the prompt-cards, but they did not use them.

# Elementary School Teachers Learning Life-Sciences Outdoors

*Tali Tal, Irene Bayer and Kara Haas*

**Keywords:** Teaching Science Outdoors, Inquiry, NGSS, Professional development, Teachers

**Type of presentation:** Poster

Teaching Science Outdoors professional development program (TSO) is a research collaboration between science educators and a biological research station in Midwestern-university in the US. TSO aims at helping elementary school teachers teach life sciences in authentic ways, using multiple resources and the Next Generation Science Standards (NGSS) to guide their teaching. We focus on elementary teachers because of their relatively limited content knowledge.

This research is looking at ways to bridge classroom and outdoor teaching and learning. This view sees distinction between formal and informal science education as outdated and artificial. We used the “Hands, Heads and Hearts” method used in the context of service learning in both the classroom and outdoors. In the US, where the study took place the K-12 Framework for Science Education, the Next Generation Science Standards and Teaching Science in Informal Environments were used to design TSO, in addition to literature on inquiry learning, outdoor education and on effective teacher PD. Altogether, we have followed 70 teachers with varied teaching experience during a 4-5-day program, and through activity on the program website. We focus on some lessons learned from our experiences during 2014-2017. We examined the ways outdoor investigations affected teachers’ engagement with biology and willingness to teach in the outdoors.

The focus of TSO-PD is on how teachers can use available resources such as schoolyard, nearby city parks or woods to teach in the outdoors.

Data encompassed: pre/post online open-ended questionnaires, online daily reflection sheets, semi-structured interviews and analysis of teachers work. Analysis was mainly inductive.

Teachers believed that outdoor investigations were authentic and engaging. Quiet time for reflection was emphasized, as well as working in teams.

Learning how to investigate using variety of tools was new to many teachers, as well as thinking about inquiry questions together, making predictions and discussing the importance of students asking the questions. Collaborative work was highly appreciated. Technology was central in TSO: all activities and materials were on the program-website, and mobile-tools were used outdoors. All teachers acknowledged the contribution of technology, but differed in proficiency and in the extent they used it in the field.

TSO enabled working with local teachers on using authentic outdoor environments toward teaching science in more productive ways. Teachers overcame their novelty and gained more confidence. We stress that when a PD is carefully designed addressing teachers’ needs and standards, there is greater chance that teachers will teach outdoor-inquiry.

# Understanding immunobiological processes – Using everyday conceptions in group discussions

*Sonja Tinapp and Jörg Zabel*

**Keywords:** Peer learning, Conceptual Understanding, Immunobiology, Group discussion, Design-Based Research

**Type of presentation:** Oral

In recent decades, new infectious diseases have been discovered. In addition re-emerging pathogens caused new outbreaks under different environmental conditions. The ever-growing findings of immunobiology are getting more important for teaching biology, especially in the field of health education and promotion. Empirical studies on learner perspectives regarding microorganisms and the immune system show that the immunobiological processes are difficult to understand. They take place on a molecular and cellular level and are not directly relatable through experience. Despite several decades of pupil conception research on this theme, the results still do not influence everyday biology lessons substantially, and have rarely led to new teaching-learning strategies. Our objective is to develop and evaluate a learner-oriented teaching unit on immunobiology, based on learning potentials. In this paper, we focus on the efficacy of a discursive exchange of everyday conceptions within peer groups to support the understanding of immunobiological topics. Framed by the Design-Based Research approach, the evaluation results directly inform our teaching practice. Against our theoretical background, we formulated design principles and developed a teaching-learning arrangement, including peer group discussions.

Two research cycles were conducted so far in an urban school in Saxony (Germany). Each cycle encompassed two naturalistic 7th grade classes ( $n = 4 \times 25$  pupils, 13 years old). The discourse was documented utilising group work audio recordings and worksheets. Data from 17 groups were analysed and evaluated using Qualitative Content Analysis and Toulmin's Argument Pattern.

The data analysis showed that out of seventeen groups, fourteen gained a better understanding through peer group discourse. Seven of these successful groups had made use of the learning material during this discourse, while the other seven had decided not to use it but gained through discussion only. The remaining three groups showed no improvement.

Our results indicate that the learning environment used in the study led to a scientifically adequate perspective in fourteen out of seventeen groups. These groups successfully reconstructed their conceptions within their peer group discussion. Limitations arose when the learning material could not bridge the gap between the pupils' conceptions and the scientific notions. We conclude that under specific conditions a discursive exchange of everyday conceptions in peer group discussions supports the understanding of immunobiological topics. At the conference, a model lesson design will be presented that we consider applicable to a wider range of complex biological topics.

# Inspired by Bioinspiration at the zoo: Three case-studies

*Michal Topaz and Tali Tal*

**Keywords:** Bioinspiration, Biodiversity, Adaptations, Conservation education

**Type of presentation:** Poster

Many zoos consider conservation and education as prominent themes in their mission statements, but fail to identify the relations between the two. Zoo educators are looking for methods and didactics to link to their audience conservation and everyday actions. Bioinspiration (or: biomimicry) is an interdisciplinary methodology in which biological principles are applied to human challenges with sustainable development. In this exploratory study, we used bioinspiration as an educational approach, giving zoos opportunity to use visitor's life contexts to teach biology and conservation. We present case-studies of three women, with different characteristics, who participated in bioinspiration series of interdisciplinary meetings, taking place at the open spaces of the zoo. Each of the three participants came to the course with different expectations and experience. Participants learned about adaptations and behaviors that inspired engineers, and experienced behind-the-scenes observations of wildlife. Data were collected through in-depth interviews. We focus on adults, as part of the idea of lifelong learning, because such informal education programs are scarcely studied, although becoming very common. Teaching BI at the zoo helps getting adult visitors, who might have little to do with biology, closer to biodiversity and conservation. Participants learn and experience biology, using their own contexts and backgrounds. Each of the participants emphasized ideas relates to their everyday-life: The software engineer, which is very science oriented, was excited to learn how structures in nature inspire social applications, and the potential of antibacterial surfaces inspired by sharks to help disinfections in rural places. The retiree secretary was full of wonder about the innovative thinking methods, integrating technologies inspired by biological adaptations, such as giraffes blood pressure and its relation to astronaut-suits. And the lawyer who was enthusiastic to learn about circularity in nature and its implementation on C2C projects and the environment. All three were interested in practical application that could conserve nature. The different learning outcomes help us see BI as interesting to diverse audience.

# Effectiveness of digital versus traditional (paper-based) dichotomous keys for identification of woody species

*Gregor Torkar*

**Keywords:** digital identification keys, paper-based identification keys, woody plants, preservice teachers, botany

**Type of presentation:** Oral

The use of mobile learning (m-learning) has enabled new possibilities for learning and teaching. The research goal was to determine the effectiveness of digital dichotomous keys vs. traditional (paper-based) dichotomous keys for the fieldwork in biology education. Pre-service biology teachers from the University of Ljubljana, Faculty of Education used a digital (interactive) key on tablet computers or traditional (paper-based) dichotomous key to identify woody species in the garden nearby the Faculty. They were randomly assigned to one of the groups (digital or traditional key). Both identification keys contain the same woody species, identical photographs of the same size and same sequence of identification steps. Time and correctness of determination for five selected woody species were measured. The students completed also questionnaires about their attitudes towards using keys. The results showed the advantage of the digital dichotomous key over the traditional version in time needed for the determination. There were no significant differences in the correctness of determination of woody species. The students involved in the research showed very positive attitudes towards using dichotomous keys for the fieldwork in biology classes.

# Students' Reasoning About Teleological Agency

*Friederike Trommler and Marcus Hammann*

**Keywords:** teleology, agency, reasoning, explanation

**Type of presentation:** Oral

In biology education, students' teleological intuitions are considered a major learning obstacle. Students often refer to teleological agency when explaining evolutionary change. However, researchers have rarely given students the opportunity to comment on teleological agency at a meta-level. Thus, the present study analyzes students' reasoning about teleological agency to investigate the extent to which they understand teleological agency in a literal or non-literal sense. Using the context of the evolution of the giraffes' neck, the present study confronted 23 students (11 lower, 12 upper secondary level) in personal interviews with five teleological agent explanations (e.g. nature, god, organisms' will power). For each teleological agent, the students were asked whether they agreed or disagreed and to justify their choice. Based on a standard coding scheme by Rosemary Russ et al. (2008) that characterizes students' reasoning about scientific phenomena, students' justifications were coded in terms of the domain-specific knowledge used. Students mostly disagreed with teleological agency. However, 81.8 % of lower secondary level students and 50 % of upper secondary level students agreed with at least one teleological agent explanation. The reasons for their agreement respectively disagreement will be presented in this paper. Concerning domain specific-knowledge, an important finding is that students who relied heavily on the information introduced in the presented explanations tended to reason more frequently teleologically. Implications for instruction will be discussed.

# Differences in subject teachers' perceptions of their role in promoting sustainability school culture

*Anna Uitto and Seppo Saloranta*

**Keywords:** Sustainability education (SE), Subject teachers' perceptions, School culture, Secondary school

**Type of presentation:** Oral

Sustainability education (SE) is included in the school curricula around the world. However, there is not much research on the factors contributing the success of introducing sustainability as the whole-school approach in the school. To fill the gap, this study investigates the perceptions of secondary school teachers' of their role in enhancing sustainability in the school culture. A survey was used to study 442 subject teachers from 49 schools in Finland in 2010. The questionnaire included items that measured teachers' perceptions on their sustainability action (SA) in the school. Exploratory factor analysis revealed four SA dimensions, expressing teachers' action to promote sustainability policy (SP) in the school, co-operation within and outside the school (CO), social sustainability as caring the well-being of students and teachers (SW) and general every-day ecological sustainability as saving energy and materials in the school (ES). Statistical analyses showed that there were significant differences in SP, CO and ES between the subject teacher and age groups. The results indicated that teachers' agency and attempts to influence school culture was varying, so that biology, art and craft teachers were most active in promoting schools' sustainability policy. Teachers of home economics, physical education, and craft co-operated most frequently within and outside the school. However, efforts to increase social well-being and use of ecologically sustainable practices in the school were high in all subject teacher groups. More experienced teachers were more active in CO and SW than their younger colleagues. In general, the results indicated that too few subject teachers were actively working to change the school culture towards sustainability, though all teachers participated often every-day eco-sustainability activities and enhanced well-being in the school. The results suggest that it is important to support the agency of all subject teachers in schools' sustainability activities.

# Immune system model constructed by elementary pre-service teachers in a context about allergies and intolerances

*Araitz Uskola, Begoña Burgoa, Teresa Zamalloa and Gurutze Maguregi*

**Keywords:** Immune system, Modeling, Elementary preservice teachers

**Type of presentation:** Poster

Developing and using models is considered one of the scientific practices to be set in science teaching, and to be learned by elementary pre-service teachers (EPTs). One of the main models in biology is the Living Being Model (LBM) which includes the idea of all living beings differentiated from the environment, having a structure that facilitates processes to interchange matter and energy with the environment and that make changes in both the living being and the environment. This study is focused on the Immune System Model (ISM), linked to the LBM. This research analyzes the knowledge constructed by EPTs about allergies and food intolerances, and the ISM constructed by EPTs.

To carry that research, the answers of 124 first year EPTs before and after taking part in activities around immune system and digestive system and that included construction of physical dynamic models, have been analyzed. We have determined some levels of performance in students' responses. For the symptoms of the pathologies, three levels have been proposed, based on mentioning the correct symptoms and on the ability to link the symptoms and the processes inside the body. For the ISM, the levels used were previously proposed and are based on referring to the components of the LBM.

The results show that initially very few EPTs refer to immune system when talking about allergies (8.9%) or to the lack of an enzyme when talking about food intolerances (5.7%). They mention symptoms of allergies but don't refer to the processes causing them (4%). After taking part in the activities, the results show improvements in both the reference to immune system (80.7%) and lack of enzyme (66.1%), and to the linkage between processes inside and outside the body (29% for allergies, 28.2% for food intolerances). The ISM expressed by EPTs also improves, initially only 2.4% refer to the body as an active system that reacts and produces antibodies and finally 66.1%.

These improvements may have been produced by reasoning facilitated by teachers, especially during discussions about the expressed models. However, students still seem to have difficulties in linking the external and internal processes, which will have to be taken into account in future interventions. One of the implications can be a change in the acting of teachers, that can ask explicitly for that link, and help students make the connections while they are creating their dynamic physical models.

# Teaching to teach the model of evolution in Primary Education: an experience with pre-service teachers at a Spanish university

*Lucía Vázquez-Ben and Ánxela Bugallo-Rodríguez*

**Keywords:** model of evolution, teaching strategies, pre-service teachers, primary education

**Type of presentation:** Oral

Many experts consider necessary to start working on the model of evolution as soon as possible, that is, in primary or even infant education. Reasons are various, but we may focus on the centrality of evolution in Biology and all obstacles and misconceptions high-school students often face when learning about this issue. Nevertheless, to promote students' understanding of evolution, we must first provide our teachers of the appropriate knowledge and skills. Consequently, at the University of A Coruña (Spain), we resolved to work intensively on the model of evolution with our primary school pre-service teachers.

This oral communication introduces, therefore, the set of activities we presented to our undergraduate students regarding this issue on the academic year 2016/2017. In order to develop not only their comprehension of the model but also their pedagogical knowledge, all activities were intended to be varied, motivating, practical and, above all, applicable in their future career.

As a result, we decided, first, to make our students work in small groups, so that each one could deal with a different topic related to the evolution model (fossils, inheritance, natural selection, adaptation...), a different task and different materials. Secondly, most activities were directly adapted from pre-existing activities which were meant for, or had been applied, in a real primary school setting. Lastly, to encourage critical reasoning and debate, we asked our pre-service teachers to evaluate the content, methodology and resources suggested in each case from a didactic perspective. A worksheet was specifically designed and supplied for this purpose.

Following a qualitative approach, data was collected through participant observation and the already mentioned worksheet. After analysing our students' performance and comments, we found that most of them would be willing to apply these activities in their future classrooms, emphasising how innovative and motivating they were. However, they struggled to establish which content they were working on, revealing a limited grasp of the model.

Although tentative, these results have allowed us to identify some strengths and limitations to our proposal. For example, working each group in a different task proved to be effective to explore more content at once. Besides, solving real activities made our students' to perceive the assignment itself as useful for their training. Nonetheless, practicing in advance the use of models and modelling in Science Education as well as reflecting over the activity as a whole group once it is completed would be desirable.

# **No Escape: the rise of Escape Rooms in secondary biology education. What do teachers and students perceive as the educational potential of Escape Rooms in secondary biology education?**

*Alice Veldkamp, Marie-Christine P.J. Knippels and Wouter van Joolingen*

**Keywords:** educational Escape Rooms, interactive learning environments, game-based learning, learning activity, collaborative learning, students' interest and motivation

**Type of presentation:** Oral

Since the creation of the first Escape Room (ER) in 2007, the phenomenon has risen to immense global popularity in the entertainment industry. Nowadays, ERs are gaining popularity as learning environments for secondary science education. Projects such as Breakout EDU promote the introduction of ERs and claim that they result in motivated, active students who work together on content knowledge while developing skills in communication, collaboration, critical thinking, and creativity. Despite increased implementation in education no research is known yet in relation to ERs in secondary education.

In this paper, the education potential of ERs for secondary biology education is explored and determined regarding possible learning goals and their usability and feasibility in classrooms. Therefore, the views of participants in an educational biology Escape Room were analysed. One hundred biology classes in 100 secondary schools took part in a national "Escape the Classroom" event. Classroom observations were made in fourteen classes. Afterwards, eleven teachers and 69 students were interviewed, in 17 groups consisting of three to six students (aged 11-14). Furthermore, 39 teachers and 202 students responded to an online questionnaire.

This paper presents a summary of the outcomes on teacher and student views. Out of the 50 teachers who were interviewed or filled in the questionnaire, 42 indicated that they intended to do an educational ER again. The most often assigned triggers for learning were: the game element, the (doable) challenge and the unknown prize. Of the students, 90% would like to do another ER. According to them, you need to "think deeply" in the ER and be more "mutually dependent" than in usual team tasks. Both groups agree on the ERs' usability for education for various, but not all, possible learning goals. In interviews, unlike the teachers, students were skeptical about using an ER for assessment. On the aspect of feasibility, some teachers assigned the balance of "learning outcomes of students versus time investment for the teacher". Results show that Escape Rooms have educational potential for secondary biology education. However, the claimed developed skills such as communication, collaboration and thinking skills, appeared to be needed in order to understand and solve the content based activities. In ERs, learning biology, and the social skills required, should be supported by a teacher skilled in monitoring, guiding and debriefing. Currently, we are analysing the classroom observations in order to develop guidelines for educational Escape Rooms.

# Systems thinking and the theoretical nature of seeing coherence

*Roald Verhoeff, Melde Gemma Regina Gilissen and Marie-Christine Knippels*

**Keywords:** systems thinking, coherence, biological systems, literature study

**Type of presentation:** Oral

Systems thinking has become synonymous to developing coherent understanding of complex biological processes and phenomena from the molecular level to the level of ecosystems. The importance of systems and systems models in science education has been widely recognized, as illustrated by its definition as crosscutting concept by the Next Generation Science Standards (2013). However, there still seems no consensus on what systems thinking exactly implies or how it can be fostered by adequate learning and teaching strategies in secondary education. In this paper we stress the theoretical or abstract nature of systems thinking. Systems thinking is not just perceived here as ‘coherent understanding’, but as metacognitive learning strategy in which systems theoretical concepts are deliberately used to explain and predict natural phenomena. Based on a literature study on empirical reports on teaching or assessment strategies on systems thinking, we argue that systems thinking is not to be defined as set of skills, that can be learned ‘one by one’, but instead asks for consideration of systems characteristics and the systems theories they are derived from—such as the systems boundary or the vertical coherence between systems at different organizational levels that cannot per sé be perceived by the senses.

To bridge the gap between theoretical notions of systems thinking and educational practice we did a literature search on empirical studies that reported on ‘teaching strategies’ or ‘student assessment’ of ‘systems thinking’ in biology education. Preliminary results showed 10 relevant studies which were further analysed on the extent to which explicit attention had been given in classroom practice to the matching of natural phenomena to underlying system theoretical explanations, i.e. derived from general systems theory, cybernetics and dynamic systems theory.

Preliminary results show that there is no consensus on what coherent understanding of complex systems entail, or how it should be fostered. Limitations in students systems thinking abilities have been related to a lack of awareness of general patterns of systems interactions. Explicit reference to aspects of systems theories, and thereby addressing the theoretical nature of coherence, is suggested.

# Bringing together what belongs together: theory & practice and children & nature

*Lara Weiser and Annette Scheersoi*

**Keywords:** Interest, Early years, Biology learning outside the classroom, Inquiry-based learning

**Type of presentation:** Oral

Interest plays a major role for successful learning, as it is seen as an important precondition for motivation. This is also true for biology learning and for learning in the early years, when children make their first experiences with nature and its phenomena. The support of children's interest development and thus the emergence of a foundation for lifelong, joyful learning can be successful through inquiry-based learning. However, this approach is considered as very challenging for children, as well as their teachers. Settings outside the classroom may provide helpful circumstances for inquiry-based learning with children and also enable them to make first hand experiences, while conducting authentic, age-appropriate biological research. To support the implementation of the inquiry-based research approach in practice with children between three and eight years and thus their interest development, this PhD project aims to develop learning activities and teaching materials. These materials and activities can be used by kindergarten- and primary school teachers, in order to perform this approach with their children in authentic contexts outside the classroom. Methodologically, the project uses the design-based research approach to develop these materials and activities in close cooperation with teachers, scientists and particularly children from the very beginning to ensure the consideration of their needs and ideas. Different qualitative methods like participant observations and interviews are used to get an insight in the suitability of the materials and activities, as well as the children's interest development. The learning activities and teaching materials are developed through different cycles of evaluation and adaptation. The aim is to ultimately obtain approved offers for pedagogical practice and moreover new findings for the interest theory, and more specifically the biology related interest development of young children. The data analysis shows that in the context of inquiry-based learning, only specific tasks are meaningful to perform in out of school settings. In accordance with the findings, it is advisable to focus on tasks like observations, collections or determinations more than methods like fair tests and presentations, which can also be performed in classrooms in a similar way. The findings concerning the children's interest development show that the three basic needs (need for autonomy, social relatedness and competence) play a key role in early childhood already.

# **“This curse of knowledge...” How do biodiversity scientists connect their expertise to their understanding of nature?**

*Judith Wiegelmann and Jörg Zabel*

**Keywords:** Biodiversity experts, Model of Educational Reconstruction, Group Discussions

**Type of presentation:** Oral

Most research in biodiversity education uses scientific knowledge as the only measure to describe a lack of laymen understanding. In contrast, other authors emphasize that people have various mental constructs of biodiversity, often referring to outdoor experience and emotions towards nature rather than to scientific definitions (Fischer & Young 2007, Buijs 2008). Therefore, the underlying assumption of this study is that in order to teach and to conserve biodiversity effectively; both the learners' subjective nature experiences and their scientific understanding have to be connected. Furthermore, assuming that experts in biodiversity research are generally able to link their professional knowledge to their personal relation to nature, these experts' effective strategies might serve as a model for the laymen. Research in science education has already benefited from the use of discipline-specific scientific expertise for improving instructional practice.

Our research question is: How do biodiversity researchers understand nature, and how do they reconcile their subjective and biographical notions with their scientific knowledge of biodiversity? With respect to the Model of Educational Reconstruction (Duit et al. 2012), we subsequently discussed the learners' perspectives on nature with the experts, using group discussions (n=3x3). All data were analysed through Grounded Theory methodology (Strauss & Corbin 1996). To acknowledge the experts' voice, including their own unique vocabulary, we used in-vivo codes. Our results show that 4 out of 9 scientists perceive a conflict between their relationship towards nature and their everyday work. In this context, a few participants are able to use a “bilingual“ approach, meaning that they have developed effective strategies for positively connecting their current relationship with their scientific knowledge. So far, we reconstructed three of these strategies: perceiving the contradiction, separation, and imaginative visualisation.

# Context-dependency of beliefs in genetic determinism: Indications for a mind-body split?

*Johannes Zang, Tim Heemann and Marcus Hammann*

**Keywords:** genetic education, genetic determinism, mind/body, split (MBS), context effects

**Type of presentation:** Oral

Beliefs in genetic determinism (BGD) are associated with racism, stereotyping as well as prejudice and they are suspected to cause severe learning difficulties in genetics. Research findings suggest that peoples' reasoning about the formation of traits follows dualistic assumptions by differentiating between body-related and mind-related traits. This mind/body split (MBS) is characterized by attributing a stronger impact of genes on the formation of bodily traits, compared to traits related to the mind/psychological traits. Hence, we addressed the question, whether beliefs in genetic determinism (BGD) depend on the context "kind of trait" (body vs. mind). In two experiments, we tested a total of 323 subjects who completed two adapted versions of the PUGGS Section 2 questionnaire, to assess the assumed importance of environmental and genetic influences on either body-related or mind-related traits. Data was analyzed by hierarchical cluster analysis and factor analysis. We used dependent t-tests to compare scale means. As hypothesized, body-related items were rated significantly higher compared to mind-related items. Together with findings from cluster analyses this strongly indicates context dependency of BGD with implications for further test development and genetic education.

# Nutrition and reproduction students' conceptions regarding to animal classification

*Noureddine Zghida and Zouhaire Lamrani*

**Keywords:** Animal classification, Alternative conceptions, Non-taxonomic criteria, Secondary school, Evolution

**Type of presentation:** Poster

The Kattmann study about student's conceptions of animal classification is not complete. It focused only in some "non-taxonomic" criteria (habitat and locomotion). Our study aims to highlight other secondary school students' alternative conceptions regarding to animal classification. The data are collected by a test intended to middle school and high school students. The test is composed by a collection of 20 pictures of animals. This study showed that the Moroccans' secondary school students having serious problems to classify animals along taxonomic criteria (acceptable scientific criteria). We found that the majority of secondary's school students are based on non-taxonomic criteria as much as: diet, mode of reproduction and relation between animal and human. The animals are classified in groups like: carnivorous, herbivorous, viviparous, oviparous, domestic and wild. These personal classifications constituted obstacles for secondary school students to understand and to classify animals using taxonomic criteria.

The percentages of the answers of the high school students are almost equal with them of middle school. Therefore, the student's alternative conceptions are almost similar and there is not a positively evolution between high school and middle school conceptions even after learning the categories of biological taxonomy in secondary high school. Finally, the biology teachers have to take into account these alternative conceptions during the planning and the management of the didactic situations for objective to develop them positively in order to apply a biological classification based on acceptable scientific criteria.

# Prepared to teach genetics in school? – Examination of beliefs about learning content and instructional practice as well as academic self-concept of prospective biology teachers

*Kathrin Ziepprecht, Katharina Gimbel and Jaqueline Jäger*

**Keywords:** teachers' professional competence, genetics, beliefs about learning content and instructional practice, academic self-concept

**Type of presentation:** Oral

Beliefs are one aspect of teachers' professional competence. This aspect includes beliefs about learning content and instructional practice (BALI) and the academic self-concept. BALI are divided into constructivist and transmissive orientations. Studies have revealed that university students in general assess their skills rather positively (i.a. Klostermann et al., 2014). Additionally, negative correlations between constructivist and transmissive BALI are reported (Voss et al., 2011). Genetics is one of the main topics in biology class. For instance, classical genetics deals with heredity as the process of passing genetic information from one generation to the next whereas molecular genetics focuses on topics such as structure and function of DNA. This study measures (Q1) which differences in the university students' academic self-concept can be described in topics of classical and molecular genetics with regard to university content knowledge (CK) and school knowledge (SK) and (Q2) which correlations exist within their beliefs, their academic self-concept and between both constructs. It is part of the "Qualitätsoffensive Lehrerbildung", a joint initiative of the Federal Government and the Länder which aims to improve the quality of teacher training. The programme is funded by the Federal Ministry of Education and Research. The sample contains 184 prospective biology teachers from 36 German university sites. To gather academic self-concept and BALI, an online questionnaire with a 4-level Likert scale was used. It was divided in two parts. The first part concerns classical genetics with 16 items (FSKunivCK\_cg:  $\alpha=.88$ ; FSKSK\_cg:  $\alpha=.89$ ) and the second relating molecular genetics with 16 items, too (FSKunivCK\_mg:  $\alpha=.93$ ; FSKSK\_mg:  $\alpha=.93$ ). BALI were measured with a genetics-specific questionnaire (15 items) containing a subscale for constructivist beliefs ( $\alpha=.79$ ) and another for transmissive beliefs ( $\alpha=.79$ ). (Q1) Prospective biology teachers rate their university CK and SK generally middle-ranged. E.g. the self-concept concerning classical genetics (MdnunivCK\_cg = 2.8) is slightly more positive ( $z=-3.6$ ,  $p<0.001$ ,  $r=0.3$ ) than in molecular genetics (MdnunivCK\_mg = 2.6). (Q2) High positive correlations exist between the various subscales of self-concept (e.g.  $r_s$  univCK\_cg/SK\_cg = .82,  $p<.01$ ). Compliant to literature transmissive and constructivist beliefs are negatively correlated ( $r_s$  tans\_BALI/cons\_BALI = -.37,  $p<.01$ ). The subscales for self-concept and constructive BALI correlate significantly positive in a small manner (e.g.  $r_s$  SK\_cg/cons\_BALI = .22,  $p<.01$ ). Studies show that students with high content knowledge and pedagogical content knowledge more often have constructivist BALI. The results of this study conform to this. It shows the same for the self-concept, if only to smaller extents.

# **Inquiry is NOT Only about Hands-On Learning: Insights into Inquiry-Based Science Education from Two Different Teachers Groups**

*Shani Zur, Tali Tal and Mahsa Tsaushu*

**Keywords:** Inquiry, epistemology, scientific discourse

**Type of presentation:** Oral

Inquiry based science education (IBSE) is a known learning strategy used in science and biology education for many years. However, evidence shows that often, inquiry teaching in schools focuses mostly on the technical aspects and it is formed in a narrow experimental manner in which students mainly test the relations between variables. Such inquiry does not reflect the nature of science and does not allow a variety of scientific methods such as descriptive, or modeling to be represented. As a result, students are less motivated to use the abovementioned skills.

In light of the above, we explore how IBSE is being perceived and conducted by pre- and in-service teachers in different settings and cultures. The aim of this exploratory study is to provide insights into the diverse views and practices that are being used by teachers who guide IBSE. By shedding light on this matter, we hope to better understand how IBSE could be better conducted in classrooms. We look at elements of culture and discourse in the different settings. More specifically the research question is: What actions and deliberations experienced and pre-service teachers in different cultures present regarding IBSE?

In line with the exploratory nature of the study, we used the qualitative-interpretative approach. Our participants included twenty-two pre-services teachers (PST) as well as seven experienced teachers (ET) who teach science in school which specializes in IBSE. Research tools were adjusted to fit the setting of each group. In the PST course we used pre-course questionnaires, collected documents and conducted focus group interview. For the ET group, we performed observations during science classes and interviewed five teachers. Interviews were also conducted with three of their students. An interpretative analysis was carried out on all the data.

Findings show a gap between the two teacher groups. They used various strategies and had different views regarding IBSE. It was clear that the ET emphasize the epistemic domain while the PST were concerned with the technical and procedural aspects of IBSE. Although teaching experience is an important factor, we believe that the different culture in the international school had the main impact on teachers rather than teaching-experience. Such differences probably affect student understanding of the scientific endeavor. It was evident that epistemic domain should be better addressed by teachers, and already in their pre-service training.

# SYMPOSIA ABSTRACTS

# SYMPOSIUM 1

## Genetic determinism and students' understanding of gene-trait relationships

**Chair:** *Michael Reiss*

**Keywords.** Genetic determinism, Genetics education, Gene-trait relationship, Students' conceptions

The gene has been operationally defined on the basis of four interdependent phenomena: genetic transmission (inheritance of traits from one generation to the next), genetic recombination (generating new combinations of traits), gene mutation (changes in DNA that generate new traits), and gene function (the way genes work and give rise to traits). Molecular genetics and the structure of DNA reveals the mechanism for replication and inheritance of genes, and explains in chemical terms the nature of mutations. However, there are no simple molecular explanations of gene function that in a mechanistic way describe how genes are expressed in proteins that in turn induce the formation of traits. Hence, the relationship between genotype and phenotype, between genes and traits are complicated to explain from a scientific viewpoint. This complexity has also been found to be reflected within genetic education, and is a source of learning difficulties for students. In many studies students' ideas have been found to be mainly limited to rules and patterns of inheritance and they have difficulties integrating process thinking and mechanistic explanations at a molecular level. Instead, students tend to think in a causal simplistic way that promotes genetic deterministic understanding of the gene-trait relationship. In this symposium we include presentations from four different countries that further explore the learning difficulties associated with the gene-trait relationship. In a study from Israel it is investigated how alternative conceptions may affect students' understanding of gene-trait mechanisms. They found that students' that had preconceptions such as "genes are traits" and "genes are bearing traits" that do not hold the potential to discover a mechanism had significantly less ability to use mechanistic explanations that involved proteins. In a German study the aim is to categorise and systematize a broad range of students' problems of explanatory coherence and based on that characterize instructional approaches with the aim of fostering explanatory coherence regarding the formation of traits. In an international collaborative study with Brazilian freshman students, the relationship between knowledge in genetics and genomics and the belief in genetic determinism is explored. No positive effects were found, i.e. knowledge in genetics and genomics did not counteract genetic deterministic beliefs. In a Swiss study the associations between target concepts related to genetic determinist conceptions and essentialist and teleological intuitions are explored by an Implicit Association Test. It was found that genetic/essentialist associations and teleological/essentialist associations were most common.

## Paper 1

# Students' Conception of the Relationship between Genes and Traits Affects their Understanding of Genetic Mechanisms

*Michal Haskel-Ittah and Anat Yarden*

Understanding genetic mechanisms affords the ability to provide causal explanations for genetic phenomena. These mechanisms have been shown to be difficult to teach and learn. In general, during the process of learning mechanisms, the step of characterizing the phenomenon is crucial. This is because characterizing the phenomenon defines the space for the existence of mechanisms that may enable to explain the phenomenon. It has been shown that students sometimes conceive of genes as traits or as trait-bearing particles. Such conceptions of genetic phenomena are not only scientifically incorrect but it seems that they do not allow the space required for a mechanism to exist. We termed these conceptions "non-mechanistic" conceptions. On the contrary, we termed the conceptions that suggest that genes are affecting or determining traits "mechanistic conceptions". This is because they hold the potential to seek for a possible mechanism to explain the phenomenon, thus reflecting mechanistic conception. In this study, we examined the relationship between mechanistic or non-mechanistic conceptions of genetic phenomena and the ability to learn the underlying genetic mechanisms. We hypothesized that since non-mechanistic conceptions may not allow the space for a mechanism to exist; students with such conceptions would not be able to incorporate knowledge about the mechanism into their prior genetic conceptions and thus may not learn the mechanism. By analysing 9th and 12th grade students' concept maps we classified students' conceptions prior to the beginning of their genetic course. Concept maps and open questions were subsequently used to evaluate students' understanding the central role played by proteins in the gene-to-trait mechanisms. During their genetic course student used a computational learning environment that was specifically designed to enhance the understanding of these genetic mechanisms. We found that 9th and 12th grade students that were classified as having non-mechanistic conceptions prior to the course were less successful at learning the mechanisms leading from gene to trait than those with mechanistic conceptions. Our results suggest that non-mechanistic conceptions of the relationships between genes and traits may create a barrier to learning its underlying mechanism. This may explain some of the difficulties students experience in understanding genetic mechanisms. In addition these results stress the importance of characterizing the phenomenon when teaching a mechanism

## Paper 2

# The Formation of Traits: A Framework for Systematizing Students' Problems of Explanatory Coherence and for Analyzing Teaching Materials in Genetics Education

*Marcus Hammann and Tim Heemann*

Explaining the formation of traits is challenging for students. This paper describes the development of a framework for systematizing students' problems of explanatory coherence when explaining the formation of traits and characterizing teaching materials in terms of the extent to which they foster explanatory coherence. For both aims, the paper draws on the literature of thinking across the different levels of biological organization and derives central categories of analysis from this literature. The following criteria of analysis were used for characterizing student explanations and teaching materials: (1) distinguishing between different levels of biological organization; (2) interrelating concepts at the same level of biological organization (horizontal coherence); (3) interrelating concepts at different levels of biological organization (vertical coherence); (4) thinking back and forth between levels/ concepts and (5) meta-reflection about the question, which levels have been transected and which concepts have been interrelated. Categories for systematizing students' problems of explanatory coherence were formed inductively and deductively; they emerged from a review of student explanations described in the genetics education literature and interviews with students (N=7; age 16) who were asked to respond to gene-deterministic statements. The categories were tested and refined by developing new tasks which required students (n=10) to explain the formation of traits. As examples of the categories formed, students' explanations were characterized in terms of vertical coherence as confusion of levels (also called slippage of levels), when the students argued that traits (rather than genes) are inherited from one generation to the next (confusion of phenotype and genotype) and disconnects between the levels of biological organization, when students argued that genes code for traits and thus established direct links between genotype and phenotype (truncated explanations). In terms of horizontal coherence, disconnects between concepts at the same level of biological organization were observed, when students argued that genes and the environment contribute separately to the formation of traits but do not interact (two-track model). As a related finding, analysis of teaching materials for genetics education revealed a lack of teaching materials for gene-environment interactions in the formation of complex traits as well as a lack of materials encouraging meta-reflection (5). This study is the first step in understanding the need to improve existing teaching materials for the formation of traits and testing their effectiveness in terms of fostering explanatory coherence in students.

## Paper 3

# Investigating the Relationship Between Beliefs in Genetic Determinism as Related to Knowledge in Genetics and Genomics

*Niklas Gericke, Rebecca Carver, Jérémy Castéra, Neima Alice Menezes Evangelista, Claire Coiffard Marre and Charbel N. El-Hani*

Genetic determinism can be described as the attribution of the formation of traits to genes, where genes are ascribed more causal power than what scientific consensus suggests. This belief is especially problematic when it engenders intolerant attitudes such as racism and prejudice against sexual orientation. The rationale for this is a naturalistic fallacy in genetic deterministic discourse, assuming that what is natural (in this case genetically predetermined) is inherently good or right.

In this study we investigate the relationship between belief in genetic determinism and knowledge of genetics and genomics. The aim is to examine whether knowledge in genetics and genomics can counteract the development of beliefs in genetic determinism. From a scientific point of view there has long been awareness that the description of the gene as an active agent determining phenotypic traits by itself is a ‘strawman model’ used in genetic studies as an instrumental model focusing on the genetic factor ignoring environmental factors. Moreover, in the last decades the development of genomics and epigenetics has reinforced the notion of gene action as probabilistic and mutually interdependent with the environment through gene activity regulatory processes, further reducing the understanding of genes as sole active agents in the construction of phenotypes. Hence, one can conjecture that knowledge in modern genetics and genomics counteracts beliefs in the excessive power of genes and, thus, beliefs in genetic determinism.

We gathered and analyzed statistically data by means of a newly developed questionnaire instrument, “Public Understanding and Attitudes towards Genetics and Genomics” (PUGGS), applied to a group of 427 Brazilian freshmen university students. The results shows no correlations between belief in genetic determinism and knowledge in genetics and genomics. Hence, this study does not give empirical support for the argument that enhancing genetic literacy can prevent genetic deterministic beliefs. There were however indications that social factors (age and religiousness) may have importance for the formation of genetic deterministic beliefs. The result also shows that belief in genetic determinism is a complex construct that seems to differentiate into two constructs or belief systems: a belief in social traits and a belief in biological traits. The study did not give any support for the existence of widespread beliefs in genetic determination of social traits. This is an unexpected result, which contradicts much of what has been suggested in the literature.

## Paper 4

# Students' implicit associations between genetics concepts and essentialist/teleological intuitions

*Kostas Kampourakis, Florian Stern and Andreas Müller*

Research in genetics education has documented persistent students' misconceptions related to genetics. One of these is genetic determinism, the idea that genes invariably determine single or complex traits, independently of environmental factors. At the same time, we know that misconceptions in biology can stem from psychological intuitions. For example, design teleology, the intuition that the features of organisms exist for a purpose which is the outcome of intention or design, and psychological essentialism, the intuition that organisms have fixed essences, have been found to be conceptual obstacles for understanding of evolution. The aim of the study is to investigate the extent of the implicit association between these two intuitions and secondary students' genetic determinist conceptions. To this end, we used an implicit measurement instrument, known as Implicit Association Test (IAT). The IAT measures the differential association of two target concepts that appear in a 2- choice task (e.g. concepts related to genes vs. concepts related to environment) with an attribute that appears in a second task (e.g. words indicating purpose vs. words indicating no purpose). The implicit association test requires special software that displays categories on the screen and lets the participant make associations between them by pressing one of two keys on the keyboard to show with which of the two choices the concept presented is associated. Overall, 276 IATs were administered to 14 to 18 years old secondary school students from January to June 2017. The completion of each test lasted for 15 minutes on average. Nine terms were chosen per each category (genetic determinism, psychological essentialism and design teleology) based on the existing literature and on 50 semi-structured interviews conducted in September/October 2016. The list of words was revised in May 2017 accordingly to students' feedback. We found that the essentialist/genetics (resp. teleological/essentialist) associations were found among 41% (resp. 43%) of the students while the essentialist/environment (resp. teleological/environment) association was only found among 27% (resp. 28%) of the students, and no or little association was found among the remaining 32% (resp. 29%) students.

## SYMPOSIUM 2

### Understanding and Acceptance of Evolution in the Light of Threshold Concepts

*Chair: Utte Harms*

**Keywords.** evolution understanding and acceptance, abstract threshold concepts, visualizations

Evolution is a major goal in science education but presents considerable difficulties in teaching and learning. Even though a rich body of research has explored student alternative conceptions of evolution and their relationships to evolutionary knowledge and acceptance, this work has not explored the potential contributions of student thinking about abstract underlying threshold concepts like randomness, probability, or time. Indeed, it is likely that e.g. proficiency in statistical thinking impacts evolutionary thinking given the intimate connections between these domains. Fostering the understanding of threshold concepts might increase evolutionary knowledge. Visualizations – like simulations and animations with or without instructional support - are tools expected to be helpful to capture evolutionary random and probable processes and facilitate an understanding of time, one of the threshold concepts required for an understanding of evolutionary events such as speciation. Against this background this symposium unifies four contributions from three countries dealing with the meaning of the mentioned threshold concepts for improving evolution learning. The first paper focus on the analysis of written explanations on natural selection to find methods for clustering evolutionary explanations in terms of their conceptual content. The objective here is to elucidate which connections learners reconstruct between relevant evolutionary concepts and whether this leads to a coherent explanation. The second paper aims to explore (1) the relationships among knowledge of the threshold concepts randomness and probability, knowledge of evolution, and acceptance of evolution, as well as (2) the degree to which knowledge of randomness and probability can serve as a predictor of understanding and acceptance of evolution. Paper three and four report on the results of two intervention studies applying visualizations focusing randomness and probability, respectively time in evolutionary contexts to support evolution learning.

## **Paper 1**

### **Using cluster analysis for categorization of student explanations of natural selection**

*Andreas Göransson , Daniela Fiedler , & Lena Tibell*

Evolution is a major goal in science education but present considerable difficulties in teaching and learning. Biology often demands explanations that are counter-intuitive and complex, where learners need to integrate several causes into a coherent whole for a complete understanding. An effect of this is that learners tend to attend to surface features and overlook deeper structural connections when dealing with problems that have a structural similarity but differ in surface features. This presents an obstacle to deeper understanding, for example item features in evolution assessment is well known to affect learners explanations. Assessment of evolution understanding in research usually employs multiple-choice items or open-ended items. Open ended items are often scored according to the presence of so called key concepts in learners explanations of natural selection. An acceptable scientific explanation should include a causal account of the mechanism at work. While the presence of concepts mirrors learners explanations to a certain extent, the connections learners make between the concepts into a coherent explanation has been less focused in research. Hence, the key objective of this paper is to find methods for clustering evolutionary explanations in terms of their conceptual content. The talk will present some findings from cluster analysis of written explanations of natural selection. It will also discuss ways to proceed for conducting deeper analysis of the structure of learners reasoning about evolution.

## Paper 2

# Knowledge of Randomness and Probability as Predictor for Understanding and Acceptance of Evolution

*Ross Nehm, Daniela Fiedler, Gena Sbeglia, & Ute Harms*

Even though a rich body of research has explored student alternative conceptions of evolution and their relationships to evolutionary knowledge and acceptance, this work has not explored the potential contributions of student thinking about randomness and probability. Indeed, it is likely that proficiency in statistical thinking impacts evolutionary thinking given the intimate connections between these domains. In this study, we aim to explore (1) the relationships among knowledge of randomness and probability, knowledge of evolution, and acceptance of evolution, as well as (2) the degree to which knowledge of randomness and probability can serve as a predictor of understanding and acceptance of evolution. A total of 538 undergraduate students participated in a cross-sectional study. Correlation analyses of knowledge of randomness and probability with understanding and acceptance reveal significant small ( $r = .10$ ) to large ( $r = .56$ ) relationships. Further, regression analyses indicate that knowledge of randomness and probability explains 30.8% variance of evolutionary knowledge and 9.3% variance of acceptance. The addition of ACORNS scores significantly increased the variance explained to 35.9% and 15.0% respectively, while the inclusion of contextual factors raised the variance explained to 36.2% and 15.7% (without being significant). Our work indicates that knowledge of randomness and probability is related to understanding and acceptance of evolution and appears to be a significant but neglected factor in evolution education research.

## Paper 3

# Simulation EvoSketch: Learning Randomness and Probability in Evolution

*Daniela Fiedler & Ute Harms*

Understanding evolution is central to understanding biology, and is a key objective in school curricula. However, student understanding of evolution is not always accurate. Current research assumes that especially underlying abstract concepts such as randomness and probability may hinder successful learning of evolution. Therefore, fostering the understanding of threshold concepts might increase evolutionary knowledge. Visualizations (such as simulations) can help capturing these abstract concepts. Especially simulations, in combination with instructional support, are most effective for learning. The presented study examines whether (a) knowledge of randomness and probability as well as evolutionary knowledge can be promoted by the simulation EvoSketch, and (b) if simulation-based learning is more effective without or with additional instructional support. A sample of 220 secondary school students participated in an experimental study with four groups (text, simulation, sim-interpret, and sim-reflect). Test performances were measured on three days. Results yielded unexpected patterns. On average, learners reached lower posttest scores, while delayed posttest scores increased. Although there was no significant differences between the groups regarding test performance, groups differ in students' perceived cognitive load and intervention time. Learners in the text group sensed higher cognitive load than learners in the simulation and sim-reflect group. Further, learners in the simulation group needed lesser time to work through their tasks than learners of all other groups. There could be several reasons for the rather unexpected results. It could be assumed that learners were overstrained by learning contrainuitive concepts or they could have been overwhelmed by the high amount of new information. This might have led to a break-in of motivation and results in higher amount of random response behavior in posttest. At least, learning of abstract concepts, such as randomness and probability, perhaps need longer time than an ordinary school lesson (45 minutes). Further research with intervention times over some days or weeks is recommended. Still, it can be assumed, that the simulation EvoSketch can foster students' knowledge.

## Paper 4

### Visualizing time in evolution

*Jörgen Stenlund & Lena A. E. Tibell*

Time is a difficult concept to define and understand, let alone time required for evolutionary events such as speciation. In fact, time scale is considered as a threshold concept in teaching and learning evolution. One way of addressing this issue might be via visualizations, which offers different ways of representing evolutionary time. The aim of this exploratory design study was to investigate how various representations of time in an animation affect the way participant's apprehended different temporal aspects of hominin evolution. Two variables, i) number of timelines with different scales and ii) mode of default animated time pace – were combined to yield four combinations of time representations; either constant throughout the animation, or the animated time pace decreased as the animation reached the later parts. The animation used in the study was specifically produced for the research purpose with a design inspired by similar visualizations exhibited in museums and available online. It was designed as a map, superimposed by animated areas representing the appearance, dynamic distribution and disappearance of a chosen sample of different species, or groups of species in hominin evolution. The results reveal that “finding points in time” close the end of the animation, where the sequence of events appeared very quickly, were harder for groups working with animations with only one timeline. We also found that the ability to apprehend concurrent events can be impaired if several timelines are displayed and the animated time pace is relatively high. The ability to estimate a time interval was harder for groups working with animations with only one timeline, especially at the end of the animation where the sequence of events occurred quickly. To make correct comparisons of time intervals was relatively independent of which animation that was used with one notable exception: groups working with an animation featuring several timelines and a decreasing animated time pace, performed worst in comparing events with a duration that transgressed parts of the timeline with different scales. This result indicates that temporal scale-shift may interfere with the perception of time. Implications for teaching and outreach are discussed.

## SYMPOSIUM 3

### Thoughtfulness in Biology Education

*Chair: Marie-Christine Knippels*

**Keywords:** Thoughtfulness, Culture of Biology, Reflexivity, Creativity, Meaning-making

In this symposium we bring together diverse strands of research in biology education under the umbrella of ‘thoughtfulness’. The contemporary political atmosphere of managerialism in school education (Ball, 2003) emphasises performativity and the attainment of learning outcomes and objectives through particular teaching strategies. Thoughtfulness challenges this approach through elaborating meanings associating representations between the external (objective) and internal (subjective) worlds. Examples might be the association between the objective depiction of food webs and its symbolic representations (including hierarchies of trophic levels) and the learners’ experiences of interdependence and sense of place in the world. We suggest that thoughtfulness in biology lessons can be brought about by fostering creative and unstructured moments in the learning process, in order to leave some room for symbolic meaning-making, intuition and spontaneous approaches to the objects of learning. Intuitive ideas can then be made explicit in the classroom, which helps to develop a relationship to the learning object and contemplating ethical and moral dimensions. Thoughtfulness in biology education is structured by four epistemological pillars, and the papers cut across these. The first, Awareness of Nature, drawing on meaning in the sense of the German term, ‘Sinn’, reflects on notions of time and serenity, student irritation, bioethics, roles of myth, real ontologies, through narrative approaches. The second, the History, Philosophy and Culture of Biology, explores how knowledge is constructed in biology, putting data into a biological context and strengthening the systems approach. Thirdly, the relation of thoughtfulness to democratic citizenship involving processes of deliberation through techno-moral vignettes and reflections on the ethical and cultural meaning of biology. Finally, the role of teacher development and personal biography in supporting teachers to open spaces for transformation in the classroom in developing thoughtfulness.

Four papers from three different countries, exemplify and bring these pillars together:

1. Multi-disciplinary reflections on thoughtfulness in biology education. (United Kingdom)
2. Narratives as a way to foster thoughtfulness in biology education. (The Netherlands & Germany)
3. Students’ beliefs about neuroscientific research and their role in moral and philosophical reasoning. (Germany)
4. Thoughtful teachers, thoughtful moments, thoughtful students? - A critical reflection on the culture of learning in biology classes and biology teacher training. (Germany)

## Paper 1

# Multi-disciplinary reflections on Thoughtfulness in Biology Education

*Paul Davies, Haira Emanuela Gandolfi, Ralph Levinson & Stephen Price*

Biological sciences are one of the fastest developing disciplines. Additionally, their impact on society economically, politically and ethically is huge and is getting bigger with every passing advance. For example, discoveries through genome sequencing, genome editing, systems and synthetic biology have all occurred within the last decade, with significant progress within the past few years. The impact of this revolution in understanding of the biological world and the technology that it offers raises fundamental questions about what it is to be human and what it is to have a meaningfully long life on an ever changing planet. How then, should the way that we teach the Biosciences ensure that people of all ages understand the subject in order to have informed opinions about how the advances should be used to impact on life on Earth. To begin to address this weighty topic, we organised a seminar at the UCL Institute of Education in London. The topic of this seminar series was “Thoughtfulness in Biology Education” and the participants ranged from Bioscientists, Science education researchers from across Europe, Education philosophers, university and school teachers, informal science educators and representatives from the UK Royal Society of Biology, the UK Wellcome Trust and the UK Biochemical Society. This one-day symposium generated some very fruitful discussions of what thoughtfulness might mean in terms of Biosciences education, both in dealing with Biology as a discipline that spans the molecular, cellular, organismal and planetary realms, and in terms of considerations of justice which the term ‘thoughtfulness’ represents, for example in our relationship to non-human species. Some consensus was reached in the need to move away from a fact-based discourse of Biology competence towards a more holistic approach. This approach would encourage learners to place their understanding within the context of the whole of Biology, particularly as a discipline that impacts on such a wide spectrum of issues faced today. This would involve changes to how we teach the subject, to how we teach the teachers and to how we assess the students learning and teachers’ competencies. In this paper, we discuss the findings of the symposium

## Paper 2

### Narratives as a way to foster thoughtfulness in biology education

*Marie-Christine Knippels, Jörg Zabel, Julia Zdunek & Alexandra Slegers*

**Abstract:** The abstract language of science dominates in biology textbooks (Avraamidou & Osborne, 2009). Stories, in contrast, are likely to be a powerful tool when it comes to creating meaning and initiating thoughtful moments in the science classroom (Bruner 1996). This study aims to explore how a narrative approach can foster thoughtfulness in biology education. We present two different case-study approaches in the use of narratives. The first study uses pre-written narratives (vignettes) on synthetic biology related socioscientific issues; the second is based on audio-podcasts produced by students themselves, portraying a selected animal species. The first case study explored the classroom interaction around techno-moral-vignettes in terms of opening up personal frames and stimulating dialogue, in two Dutch upper-secondary biology classes (n=17; n=25, 15-16 yrs.). Technomoral-vignettes are future scenarios, in which possible applications and moral dilemmas are being introduced in an imaginative way. Students read the vignette and wrote down their initial thoughts and feelings, after which they clarified in pairs their initial questions. Hence, a small group-dialogue was initiated to further explore and articulate students' own values and beliefs. Classroom observations were made, students worksheets collected, group discussions audiotaped, and semi-structured 10-minute interviews with the teacher and four students were conducted. In the second case study, grammar school students in Germany (n=9; 13-17 yrs.) produced audio-podcasts about an animal species of their choice. The sample group was trained in three workshops, which included (1) selecting their species and collecting scientific information, (2) instructions on subjective genres poem; (3) technical instructions about producing audio-podcasts. All audio-podcasts were analysed for bilingualism by evaluating indicators of scientific and subjective language. Results indicated that the vignette evoked a diversity of initial emotions and feelings. Sharing and inquiring these initial thoughts in small groups of peers uncovered a wide range of values and beliefs, indicating that students' mental frameworks are activated and reflected on. The podcast production appears 'thoughtful' in the sense that it helped the pupils to transcend the merely scientific perspective and to assign personal meaning to the biological topic. This was achieved through the use of narrative and subjective language, and the analysis qualified the podcasts as 'bilingual' in the sense of Gebhard (2015). The results of both case studies generally support our assumption that narrative is able to foster thoughtfulness in biology education, at least in the described contexts.

## Paper 3

# The Role of Students' Beliefs about Neuroscientific Research in Moral and Philosophical Reasoning

*Alexander Bergmann & Jörg Zabel*

**Abstract:** As individual representations of physical and social reality, beliefs influence the way persons think, talk and interact. Knowing the beliefs students hold about a biological topic helps teachers to break down the topic's complexity, especially when it comes to moral and philosophical reasoning in the science classroom. This study investigates beliefs that students hold about neurodegenerative diseases and the development of brain-computerinterfaces by involving them in an everyday-style discourse. In a thought experiment, eight small groups of German grade 9 and 10 grammar school students (13-16 yrs.; N=32) had to decide as members of an ethical commission whether a research project investigating braincomputer-interfaces as a treatment for Parkinson's' disease should be funded. The group discussions were videotaped and analysed by means of Grounded Theory methodology. Through the analysis of the resulting discussions, 22 beliefs were reconstructed revealing different levels of abstraction. On the level of directly affected persons, the students perceived mainly positive outcomes, e.g. that brain-computer-interfaces restore the quality of life of people suffering from neurodegenerative diseases to a large extent. Therefore, students reasoned, the operational risks are justified. On a more general level, they expected society and humankind to change rapidly in a negative way, e.g. a dangerous technification of humanity and society will take place. Taking both levels of abstraction into account, the students intuitively addressed ethical and philosophical questions prevalent among the discourse between experts on the field of neuroethics. We conclude the topic is well suited to create thoughtful moments of reflection, and foster students' ability to engage in moral and philosophical reasoning. We suggest teachers should systematically explore both levels of abstraction together with their students. At the moment, we are developing teaching material that addresses the students' beliefs directly and fosters their moral and philosophical reasoning.

## Paper 4

# Thoughtful Teachers, Thoughtful Moments, Thoughtful Students? – A Critical Reflection on the Culture of Learning in Biology Classes and Biology Teacher Training

*Arne Dittmer & Britta Lübke*

This paper is part of the symposium about Thoughtfulness in Biology Education and also part of a young European network with the same title (Price, 2017). Thoughtfulness is a didactical approach regarding a deeper understanding of biological phenomena and the nature of bioscience. It is focused on a teaching style, which is open for thoughtful moments and reflections on the philosophical, cultural and ethical dimension of biology. The biological curriculum entails different topics, which invites students and teachers to think about biological phenomena and biosciences even more intensive: E.g. the fascination of nature, life, natural history, ethical issues or the cultural meaning of biology. To learn a thoughtful teaching style means that teachers learn to plan and to act in a creative, open-minded and philosophical way. In view of two studies on beliefs and experiences of students from secondary school and pre-service teacher at university, the paper investigates inhibiting influences on the feasibility of thoughtful moments in biology classes. Subject of the presentation is therefore the quality of educational processes regarding the deepness of engagement with biological phenomena and cross-curricular issues belonging to the ethical and cultural dimension of biosciences. The research question of the paper is: What conceptualizations of the culture of learning in biology classes can be reconstructed from the perspective of pre-service teachers (study 1) and from the perspective and behavior of students (study 2)? Empirical data shows the relation between learning culture in biology classes, the image of biology education, as a content-driven subject, beliefs and motivational orientation of students and teachers. There is a tension between the high relevance of a reflective and philosophical teaching style and the motivation to integrate philosophical considerations in biology classes on the one side and the rejection of such reflections on the other side, because they are not part of the culture of learning in biology classes at school and biology seminars at university. The paper discusses in light of the findings the influence of the culture of learning in teacher training courses on learning styles in biology classes. In view of the didactical approach Thoughtfulness, arguments for the integration of philosophical reflections in the education of biology teachers and biology classes will be presented.

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## **EXCURSIONS AT WEDNESDAY AFTERNOON**

### **BRIDGES OF ZARAGOZA.** A trip by kayak on the Ebro river with EBRONAUTAS

Ebro descents with ebroNAUTAS are an interpretative activity suitable for all public, with minimum physical condition requirements and no previous experience needed regardless of the kind of boat used in your trip: Choice between rafts or kayaks is generally determined by river flow conditions and confirmed about 5 days before activity. Only legal must is being able to swim, but no olympic record is neither expected or exigible (our spontaneous swimmers have repeatedly confirmed that we all float very well with a proper life jacket). It is important to be aware that this is a fluvial activity in which getting wet is very likely to happen (specially in hot summer days), so participants should dress accordingly: Shorts or swimming clothes are advisable, together with a light t-shirt and wetable shoes or sandals. Dry clothes and shoes to get changed at the end should not be forgotten (suitable changing tents will be provided at the end of the activity) and, together with all participants' not wetable belongings, will be transported from embarking to disembarking points in our "support vans". We are blessed with lovely sunny days here in Zaragoza: Do remember to bring your hat/cup and sunscreen to protect yourself from sun burning during the activity and/or while enjoying the city and its highly recommended rivershore parks. Finally, if you want to use your sun glasses or need to use your regular googles, please provide yourself with a means to keep them attached to your head.

### **BODEGAS EDRA (D.O.P. CALATAYUD).** Visit to the vineyards and wineries EDRA

The EDRA vineyard is located in the town of Ayerbe, prePirineo de Huesca, Spain. Protected Geographical Indication of Ribera del Gállego. On a draining soil and calcareous clay, Edra recovers a lethargic tradition, where the densely planted vines of Syrah, Merlot, Tempranillo, Garnacha, Viognier and Parraleta varieties, among others, produce between 1.5 and 2 Kg per vine. The EDRA vineyard is located in the town of Ayerbe, prePirineo de Huesca, Spain.

EDRA cultivates its vineyard from the respect to nature, it is an oasis in the middle of cereal and almond tree, integrates in its biodiversity, and provide organic matter of the pruning and mowing.

### **CESAURAGUSTA ROMAN THEATER.** Dramatized visit

Of the series of public buildings remaining from *Cesaraugusta*, the theatre is the best preserved of the city. For more than two hundred years it was a meeting place, a focal point for social life and leisure activities for both the city and its surrounding area, playing a significant role in transmitting the cultural, political and religious values of the Roman Empire. Its location, at the highest point of the city mean that it overlooked, from the Ebro river to the Coso, a line of monumental buildings of which important archeological remains are preserved the city's different museums: the forum and its area devoted to the river port, and the public baths.

## **INTERNET ACCESS**

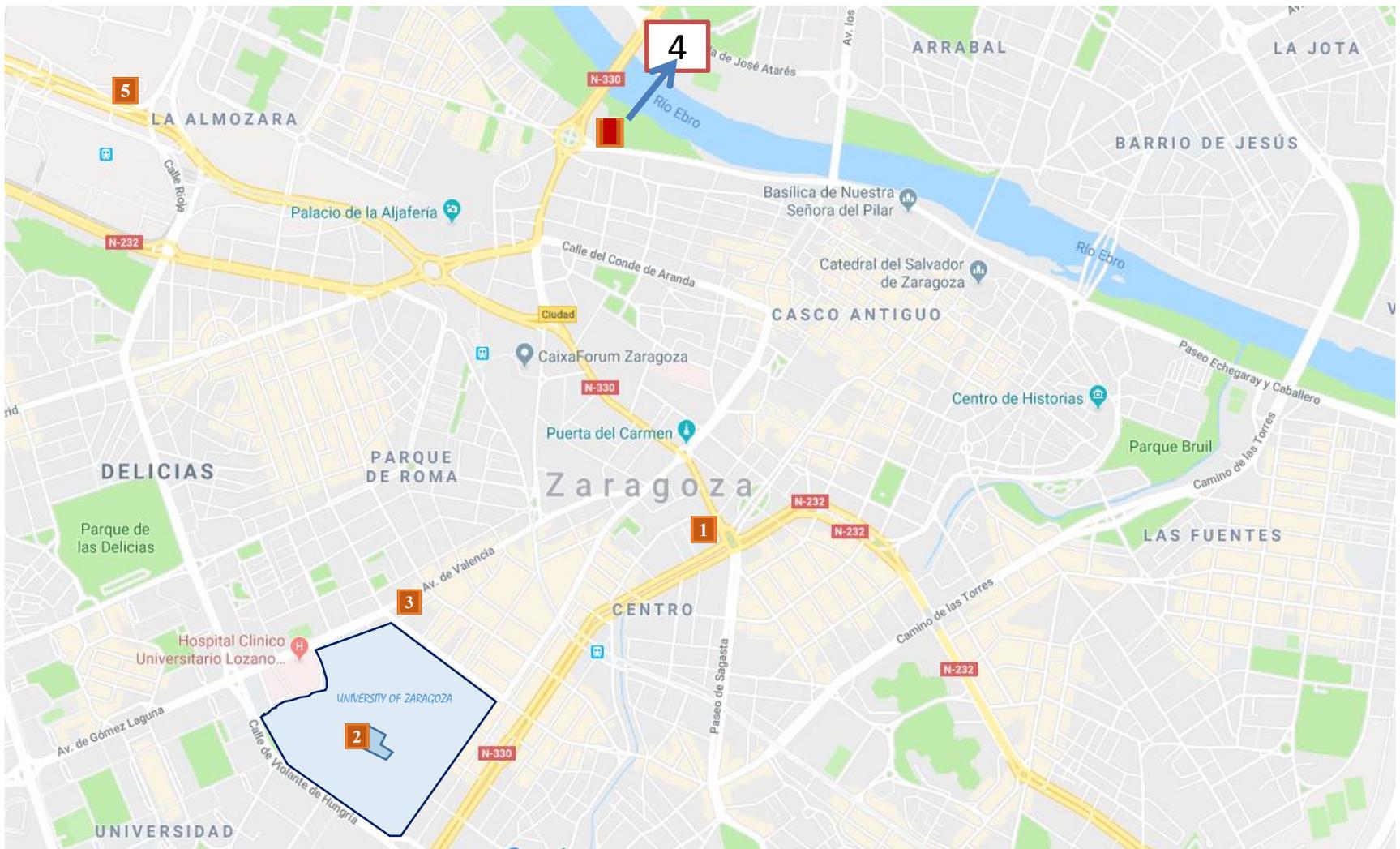
During the conference you will have internet Access to internet. Eduroam is available at Faculty of Education and Paraninfo.

At Faculty of Education you can also get a personal guest account. Printed paper letters with information will be provided in Education Faculty.

## **LOCAL TRANSPORTATION**

The faculty of education is situated within a short walking distance from the pre-booked hotels (around 20 minutes). The Tram is direct to the University (Plaza San Francisco) and takes about 5 minutes from the pre-booked hotels; you can buy a special card, in the Tram office in Gran Via, that let you travel both by bus and by tram. The minimum charge is 5 €plus 2 €deposit. You can charge this card in banks and at the vending machines that you can find in every tram stop. Moreover you can buy a ticket (1,35€) directly at the vending machines at every stop.

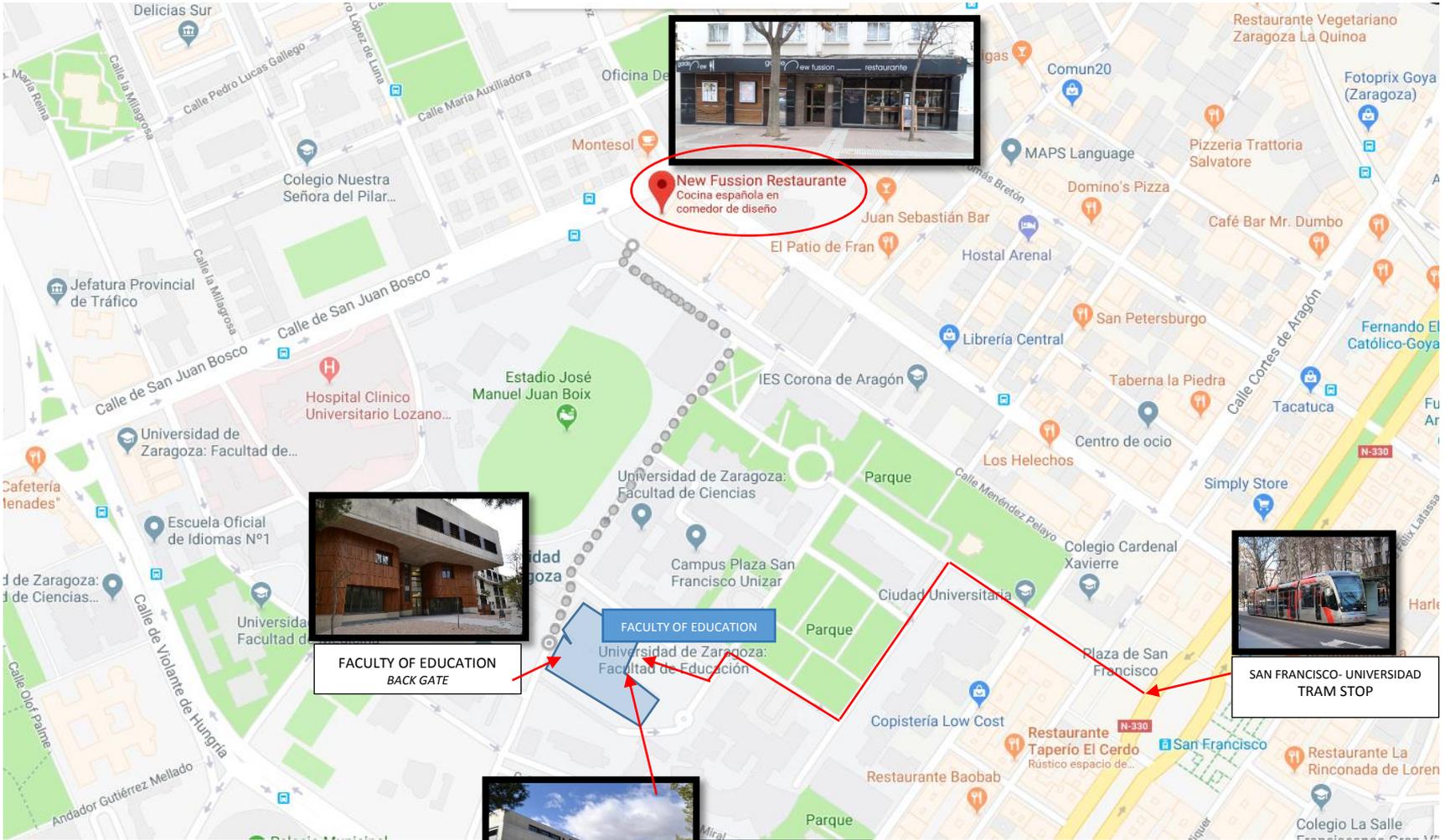
<http://www.tranviasdezaragoza.es/en/>



# Zaragoza

*Points of interest*

- 1 **PARANINFO** – WELCOME & EXCURSION MEETING POINT [Basilica Paraiso Sq., 4, Zaragoza]
- 2 **FACULTY OF EDUCATION** – ERIDOB CONGRESS PLACE [Pedra Corbuna St., 12, Zaragoza]
- 3 **NEW FUSSION RESTAURANT** – DAILY LUNCH [San Juan Bosco Ave., 3, Zaragoza]
- 4 **AURA RESTAURANT** – DINNER July 5th [José Atarés Ave., 7, Zaragoza]
- 5 **DELICIAS RAILWAY STATION** – [Navarra Ave., 80, Zaragoza]



**New Fusion Restaurante**  
Cocina española en comedor de diseño



**FACULTY OF EDUCATION**  
BACK GATE

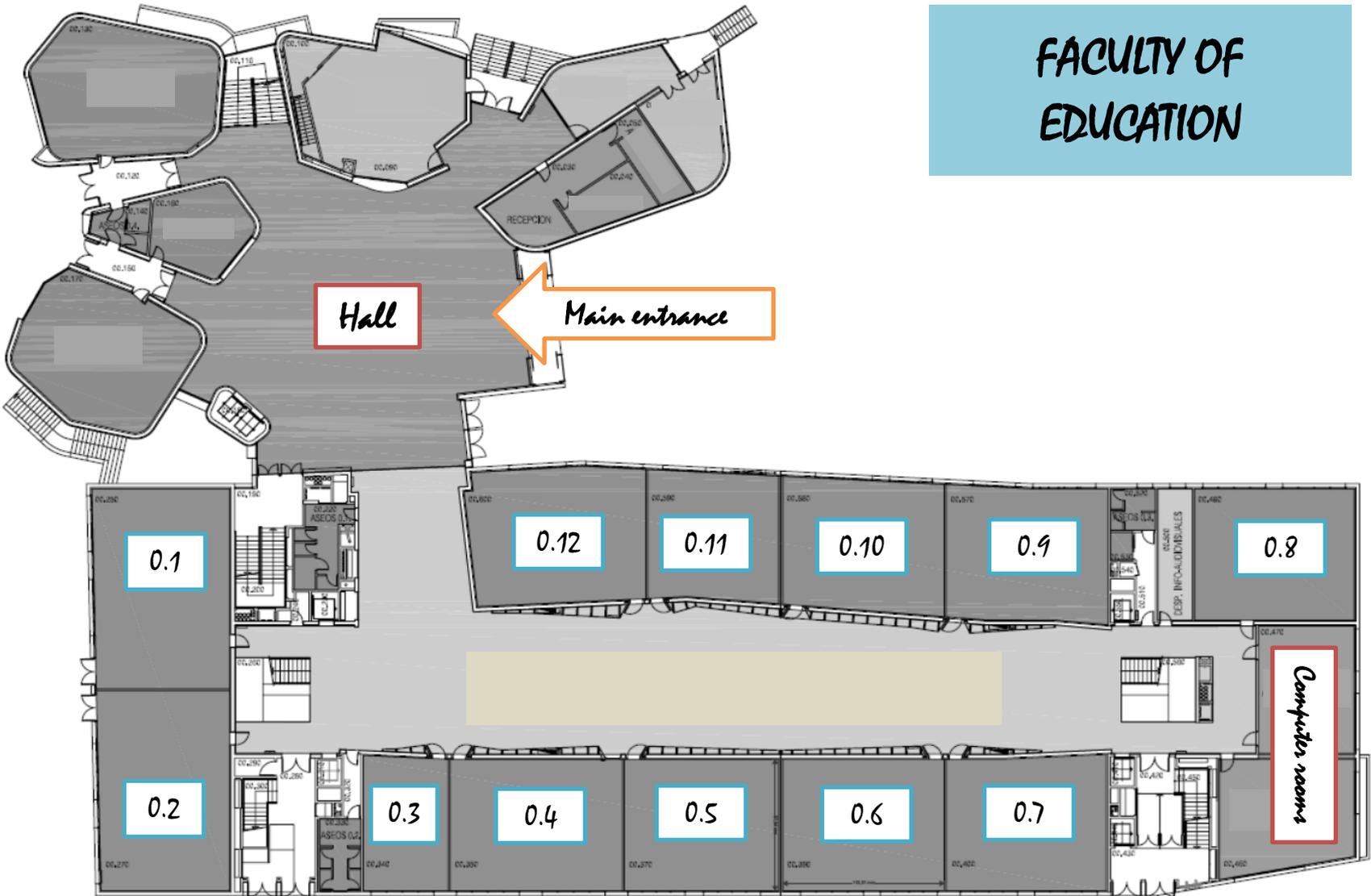


**FACULTY OF EDUCATION**  
FRONT GATE



**SAN FRANCISCO - UNIVERSIDAD**  
TRAM STOP

# FACULTY OF EDUCATION



GROUND-FLOOR

