12th International Conference on Conceptual Change

"Learning with Conceptual Change in higher Education and Professional Practice"

Program and Book of Abstracts

24 – 27th of August 2022
Hogeschool Windesheim – Zwolle – The Netherlands

University of Applied Sciences Windesheim

Earli

LOCATION

Hogeschool Windesheim
Campus 2
8017 CA Zwolle
Check in will take place in the Atrium at the main-entrance.

Arriving by train: Take the south-side exit (*Zuidzijde*) of the Zwolle Railway Station and walk about 10 minutes (1 km) to the Campus. The direction is indicated.

By road: Take the A28 exit number 18 "*Zwolle Zuid*". Follow the direction N337 Hogeschool Windesheim is on your right at the third traffic light. When visiting Windesheim by car, you can park on our Campus paid parking (€2,00 per day).

By air: Take a flight to Amsterdam Schiphol Airport and continue your journey by train. The train station is situated within Schiphol Airport. There is a direct InterCity service to Zwolle every 30 minutes. The trip takes a little more than an hour.

International Steering Committee:

Gertraud Benke, Alpen-Adria University, Klagenfurt, Austria
Jake McMullen, University of Turku, Finland
Erik Meij Windesheim University of Applied Sciences, Zwolle, The Netherlands
Andreas Obersteiner, Technical University of Munich, Germany
Christian Thurn, ETH Zurich, Switzerland

Local organization:

Lucienne van der Velde & Erik Meij

We thank Windesheim University for their support.

We thank our session chairs:

Shulamit Kapon, Terhi Mäntylä, Wim van Dooren, Konstantinos Christou, Peter Edelsbrunner, Cecilia Lundholm, Ines Langemeyer, Eric Klopp, Michel Bélanger

We thank our panelists:

Martijn Meeter, VU University Amsterdam, The Netherlands
Bruno Oldeboom, Windesheim University of Applied Sciences, Zwolle, Netherlands

We appreciate the time and consideration our reviewers took to consider the submissions:

Ada Abes, Andreas Obersteiner, Anna-Leena Kähkönen, Barbara Hanfstingl, Christian Schons, Christian Thurn, Elena Xeni, Eric Klopp, Erik Meij, Evelyn Kobler, Gertraud Benke, Helen Margaritou-Andrianessi, Ilona Södervik, Ines Langemeyer, Jake McMullen, James Vivian, Konstantinos Christou, Kristi Mets-Alunurm, Leonie Brummer, Manal Raoui, Mariana Levin, Peter Edelsbrunner, Raquel Ramos, Stamatis Papadakis, Stefânio Ramalho do Amaral, Tamer Said, Ton Zondervan, Wim Van Dooren, Xenia Vamvakoussi, Ying-Chih Chen

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WELCOME

Dear Colleagues,

On behalf of the organizing committee, we warmly welcome you to Zwolle, for the 12th International Conference on Conceptual Change. Two years later than originally planned, we are excited to finally have the opportunity of an on-site meeting. We especially welcome new members of our community, who may not have had the opportunity to meet other members of our SIG in person.

The theme of this conference is Learning with Conceptual Change in Higher Education and Professional Practice. The aim is to look at the role of conceptual change in adult learning in professional contexts such as teacher education. We hope to spark discussions between researchers from different areas.
The conference theme bears on the general idea of life-long learning, which seems more current than ever, and which is not limited to professional contexts. The pandemic has fueled discussions about the role of science and scientific understanding in the broader public. Technical terms like exponential growth, R-factors, or reliability of medical tests have made their way into our everyday language, and recent events force us to rethink things we have taken for granted.
Clearly, life-long-learning is relevant to everybody, and learning often requires conceptual change. We hope that this conference can contribute to a better understanding of the role of conceptual in this broader dimension.

We would like to thank the local organizing team led by Erik Meij and Lucienne van der Velde, for their hard work under challenging circumstances. A special thanks goes to Gertraud Benke for her dedicated support in organizing this conference. Although Gertraud's term as a SIG coordinator ended in 2021, she was actually a key person in the organizing team. Another special thanks goes to Christian Thurn, our JURE coordinator, for taking responsibility for various activities in preparing the conference. We also thank all conference participants who contributed to this conference in many different ways, such as the keynote speakers, the session chairs, and the reviewers. Finally, we thank the Hogeschool Windesheim and the European Association for Research on Learning and Instruction (EARLI), who supported this conference.

SIG Coordinators
Andreas Obersteiner and Jake McMullen

WELCOME FROM THE JURE COORDINATOR

We especially welcome those who are participating at this conference for the first time, and/or are junior researchers. We recommend you attend our two preconference sessions on Wednesday morning. In "Writing and getting published – Some tips & tricks" Wim van Dooren will provide you with valuable information about the academic writing process, and in "Conceptual Change: What it is and what it is becoming" Konstantinos Christou will give a helpful overview of the current perspectives on conceptual change.

Those who submitted a "PhD Poster" will get feedback in the feedback session 26th of August from 12:30 – 14:30. You will receive feedback from Ines Langemeyer, Terhi Mäntylä, Xenia Vamvakoussi, Konstantinos Christou, and Wim van Dooren.
On Friday 26th we will also have our JURE symposium from 16:30-18:30. The symposium sheds light on conceptual change research in different contexts and life-phases. We have an interesting range of topics, from computer science in primary school, over mathematics misconceptions in 6th grade to chemistry teacher education and adults' engagement with science topics.
We are also happy to let you know that we could support three promising researchers with a Travel Bursary to increase diversity and researcher participation at our conference.
And finally, if you will attend the social dinner on Thursday evening and are a PhD student, you will get refunded 35€ if your university does not refund the dinner.
If you have any questions regarding junior researcher topics, feel free to contact our JURE coordinator (christian.thurn@ifv.gess.ethz.ch).

I wish you a great conference and a valuable learning experience.

Christian Thurn

GENERAL INFORMATION ABOUT THE CONFERENCE AND THE CITY OF ZWOLLE

In case of emergency

Dial 112 for police, ambulance or fire. For medical or police assistance, ask the conference staff for help. *Only in case of urgent assistance needed,* you can call +31 654 70 5665

Internet access

Upon arrival at the conference you will find the code to enter the WIFI.
The Netherlands is almost fully covered with a 4G and often 5G mobile phone network.

Social event

The social event on Thursday will be a guided city tour in the old center of Zwolle that was developed by students of the teacher education for geography. The evening dinner will be in restaurant *De Hofvlietvilla* at the *Pannenkoekendijk* that has a wonderful evening view on the town center. If you have any special dietary requirements, please inform us in advance at earli2022@windesheim.nl

Eating and drinking in Zwolle

Zwolle is quite a culinary city with a great number of restaurants. The most famous one is certainly *De Librije* which has 3 Michellin stars for years already. But also for a more regular meal there is a rich choice of possibilities (although it must be said that after the corona period which was disastrous for the hospitality industry, prices for food and drinks in the Netherlands have risen sharply). You can use the internet to see the many different restaurants available.

Supermarkets

At the railway station south exit (*Zuidzijde*), on the big square you will find a Spar-supermarket. If you walk down the *Pilotenlaan/Diasporalaan*, you will find an larger AH-supermarket. There are some smaller shops inside the railway station at the *Centrum* exit.

Electricity

220V/50 Hz voltage.

Water

Dutch water has a very good quality. Just ask in a restaurant for tap-water alongside your wine, coffee etc.

Bus connections in town

Almost all bus lines have a stop at the railway station. From there it is a 10 minute walk to Windesheim. Tickets can be bought in the bus.

Keeping fit

Windesheim has a new modern sports complex *On-Campus* where you can swim and work out, located in the *Z-building*. For opening hours, please check www.on-campus.nl/rooster for Lane Swimming (Banenzwemmen) and work out (Vrij Fitness). A 2 hours ticket costs €6.30 for swimming and €8.25 for fitness.

Biking

The Netherlands is a bike country. Dutch cities are full of bicycles and every street has separate bike lanes. Depending on your hotel of choice, you can walk to Windesheim University but for getting around town, the bike is the easiest option.
Windesheim has a limited number of bicycles to lend. If you are interested, please send an email to earli2022@windesheim.nl

Discovering the city…

The city of Zwolle got its city rights in 1230 and carries a long history with it. Several old buildings and remnants of the city walls are silent witnesses of the medieval times. Now it is a modern city with 130.000 citizens and still growing. While wandering in the old city centre you'll encounter both old and new. The two center squares (*Grote Markt* and *Grote Kerkplein*) are filled with terraces in summer time.
A few highlights that definitely are worthwhile to visit are the museum *De Fundatie* (€14,00 entrance) with the huge eye-catching egg on top and *Waanders in de Broeren*, the bookshop that is situated in an old church where you can wander around for quite some time and have a good cup of coffee or a glass of wine.

… and its surroundings. Walking.

Zwolle is on the banks of the rivers IJssel and Vecht. The dikes, the river banks and the bridges show you what is probably a most typical Dutch landscape view: flat, river, dikes, grass. Walking on the Zwolle-side of the IJssel-dike, you see the small medieval town of Hattem at the other side. These river scenes have been painted often during the Dutch 17th century golden age. If you are interested, take the foot-and-bike ferry to Hattem (€1,00) and visit the *Voerman Museum*.
If you leave the city, for a walk, you get in different landscapes in practically every direction.

PROGRAM OVERVIEW

This pdf is your conference program unless you asked for a paper printed version at registration. The paper booklet then will be in your conference bag.

Wednesday 24 August 2022

10:00 - 11:30	Preconference session 1 (Wim van Dooren)
12:00 - 13:10	Preconference session 2 (Konstantinos Christou)
14:00 - 14:30	Welcome
14:30 - 16:00	Keynote 1 (Olivia Levrini)
16:00 - 16:30	Coffee
16:30 - 18:00	Paper presentations 1 and 2
18:00 - 19:30	Reception

Thursday 25 August 2022

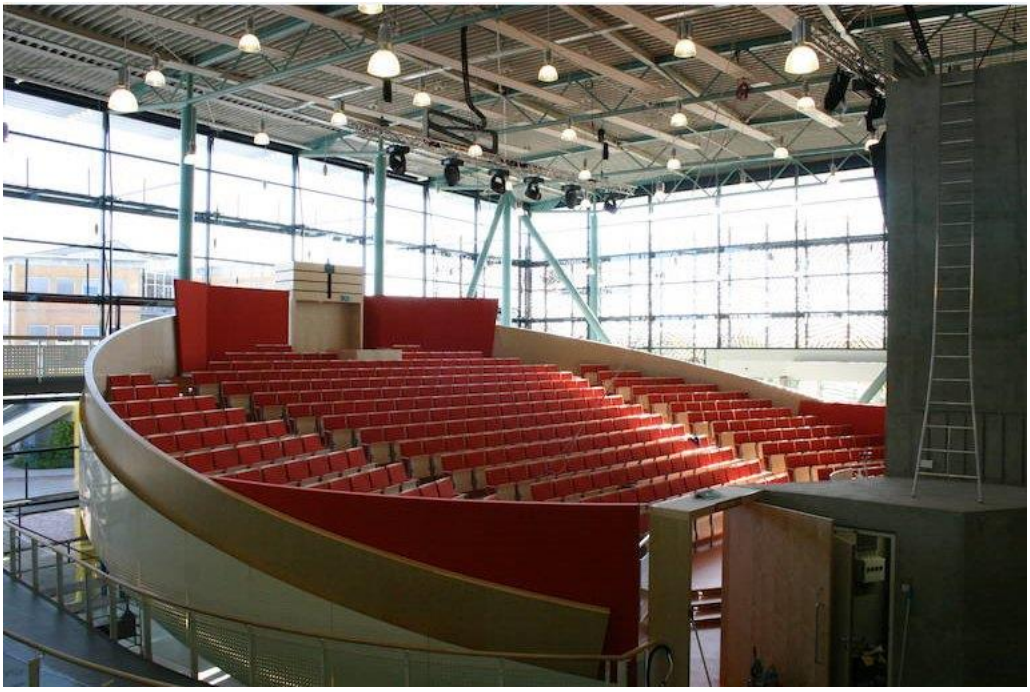
9:00 - 10:30	Paper presentations 3 and 4
10:30 - 11:00	Coffee
11:00 - 12:30	Keynote 2 (Andrew Shtulman)
12:30 - 13:30	Lunch
13:30 - 14:30	Panel discussion
14:30 - 16:30	Symposium 1 and 2
16:30 - 17:00	Coffee
17:00 - 18:30	Poster presentations
18:30 - 19:00	Break
19:00 – 21.30	Social Event

Friday 26 August 2022

9:00 - 10:30	Paper presentations 5 and 6
10:30 - 11:00	Coffee
11:00 - 12:30	Keynote 3 (Cecilia Lundholm)
12:30 - 13:30	Lunch and PhD feedback session
13:30 - 14:30	Extended Lunch and PhD feedback session
14:30 - 16:00	Paper presentations 7 and 8
16:00 - 16:30	Coffee
16:30 - 18:30	Symposium 3: JURE
18:30 -19:30	EARLI Business meeting

Saturday 27 August 2022

9:00 - 10:30	Symposium 4
10:30 - 11:00	Coffee
11:00 - 13:00	Symposia 5
13:00	Farewell



A printed version of this program time table is in your conference bag.

Time	Wednesday 24 August 2022	Thursday 25 August 2022	Friday 26 August 2022	Saturday 27 August 2022
09:00		**Paper session 3** CC in Math Education **B0.42 abstracts 7-8** / **Paper session 4** CC in Science Education **Auditorium abstracts 9-11**	**Paper session 5** Collaboration and cc **Auditorium abstracts 19-21** / **Paper session 6** Theorizing CC part 1 **B0.42 abstracts 22-24**	**Symposium 4** Pluralist perspectives on conceptual change **Auditorium abstract 32**
09:30				
10:00	**Preconference session 1** (Wim van Dooren) "Writing and getting published – Some tips & tricks" **Auditorium**	Coffee Atrium	Coffee Atrium	Coffee Atrium
10:30		**Keynote 2:** Andrew Shtulman Auditorium	**Keynote 3:** Cecilia Lundholm Auditorium	**Symposium 5** Cognitive Conflict between Science and Intuition: New Empirical Investigations and a Cognitive Model **Auditorium abstract 33**
11:00				
11:30				
12:00	**Preconference session 2** (Konstantinos Christou) "Conceptual Change: What it is and what it is becoming" **Auditorium**			
12:30		**Lunch** - Greenroom	**Lunch** Greenroom	Farewell
13:00				
13:30		**Open Panel discussion** Auditorium	**Extended Lunch**	
14:00	**Welcome** Auditorium			
14:30		**Invited Symposium 1** Supporting learners' conceptual change in mathematics: The role of teachers **B0.42 abstract 12** / **Symposium 2** Environmental challenges and education - focusing on cc and the social sciences **Auditorium abstract 13**	**Paper session 7** Theorizing CC part 2 **Auditorium abstracts 25-27** / **Paper session 8** Classroom Teaching **B0.42 abstracts 28-30**	
15:00	**Keynote 1:** Olivia Levrini Auditorium			
15:30				
16:00	Coffee Atrium	Coffee Atrium	Coffee Atrium	
16:30	**Paper session 1** CC in Teacher Education **B0.42 abstracts 1-3** / **Paper session 2** CC in Physics Education **Auditorium abstracts 4-6**	**Poster Session** Atrium **abstracts 14 - 18**	**JURE Symposium 3** Conceptual Change Research across ages **Auditorium abstract 31**	
17:00				
17:30				
18:00				
18:30	**Reception** Atrium			
19:00		**Social Dinner**		
19:30				

Pre-conference Sessions

On Wednesday 24 August, two pre-conference sessions are offered for PhD students and for guests that would like to know a bit more about the world of Conceptual Change Theory.

10:00 – 11:30 Auditorium

Writing and getting published – Some tips & tricks

Wim Van Dooren (wim.vandooren@ped.kuleuven.be), KU Leuven, Belgium

This session provides concrete information for PhDs about writing your (first) article. What's involved, the process and the pitfalls.

12:00 – 13:30 Auditorium

Conceptual Change: What it is and what it is becoming

Konstantinos Christou (kpchristou@gmail.com), University of Western Macedonia, Greece

This session provides a general overview of what the rich research framework of conceptual change involves, where we came from and the future ways to go.

Open Panel Discussion

Thursday August 25th at 13:30 – 14-:30 Auditorium

Why is Conceptual Change Theory not a leading Learning Theory in Teacher and Professional Education?

In the last decades, education is shifting from teacher and content centered towards more student centered focus. With that, there is more attention for learning in the daily educational process.
Conceptual Change Theory provides cognitive and affective perspectives on learning and describes the role of (epistemological) beliefs in one theoretical framework. And yet, it is hardly ever offered as the main theory underpinning classroom learning (although there seems to be a difference in countries). This question and more underlying questions will be discussed from the perspective of science and education.

In the open panel discussion format, a maximal interaction between the audience and the panel is envisaged.

Moderator: Erik Meij, Windesheim University of Applied Sciences, Zwolle

KEYNOTES

Keynote 1

Wednesday August 24th at 14:30, Auditorium

Unpacking change for teacher education in the era of uncertainty and acceleration

Keynote speaker :
Olivia Levrini, Professor in Physics Education at the University of Bologna, Italy.

Chair: Shulamit Kapon

Scientific and technological development has been driving fast societal changes and educational systems are struggling to keep up with the pace of such transformation. As a result, youth do not find in the "traditional disciplines" the resources needed to develop competencies to navigate a complex, fragile and fast-changing society. They perceive traditional schooling as less and less socially, personally, and vocationally relevant. This questioning of traditional disciplines has deep implications for teacher education. In this talk, I will address the following questions in reference to the field of STEM education: How can we re-imagine teacher education in this era of uncertainty and acceleration? What kind of epistemic, conceptual, and cultural change do teacher educators and teachers have to pursue to align science education to societal changes? What role will be played by the "traditional disciplines" in the educational systems of the future? Stimuli for grappling with these questions will be provided from two European projects: FEDORA (www.fedora-project.eu) and IDENTITIES (www.identitiesproject.eu).

Biography:
Olivia Levrini is an Associate Professor in Physics Education and History of Physics at the Department of Physics and Astronomy of the University of Bologna, Italy. Her current research work concerns: interdisciplinarity in STEM education; educational reconstruction of advanced current topics in physics (thermodynamics, relativity, quantum physics); cognition and conceptual change; identity and processes of appropriation; instruction design on future-oriented STEM issues (climate change, artificial intelligence, quantum computing). She coordinated the European Erasmus + Project called I SEE - Inclusive STEM Education to Enhance the capacity to aspire and imagine future careers (www.iseeproject.eu), and, currently, she coordinates the European Erasmus + Project IDENTITIES - Integrate Disciplines to Elaborate Novel Teaching approaches to InTerdisciplinarity and Innovate pre-service teacher Education for STEM challenges (www.identitiesproject.eu) and the Horizon 2020 project called FEDORA - Future-oriented Science EDucation to enhance Responsibility and engagement in the society of Acceleration and uncertainty.
She served as Conference President for the 2019 ESERA conference (www.esera2019.org).

Keynote 2

Thursday August 25th at 11:00, Auditorium

Bundles of contradiction: A coexistence view of conceptual change

Keynote speaker :
Andrew Shtulman, Professor in Cognitive Science and Psychology at Occidental College, Los Angeles, CA, United States

Chair: Peter Edelsbrunner

Before learning science, we construct intuitive theories of the natural world. Intuitive theories function similarly to scientific theories, furnishing us with explanations and predictions, but they are less accurate and less precise. In this talk, I will show how intuitive theories survive the acquisition of scientific theories, competing with those theories to provide inferences about the same phenomena. While we can learn to privilege science over intuition, we cannot eliminate the conflict between them, as revealed by priming studies, training studies, and studies with science experts. I will explore the dynamics of this conflict, its cognitive underpinnings, and its implications for theories of conceptual change.

Biography:
Andrew Shtulman is a Professor of Psychology at Occidental College in Los Angeles. He holds an A.B. in Psychology from Princeton University and a Ph.D. in Psychology from Harvard University. His research explores conceptual development and conceptual change, particularly as they relate to science education, and he is a recipient of an Early Career Development Award from the National Science Foundation and an Understanding Human Cognition Scholar Award from the James S. McDonnell Foundation. Dr. Shtulman is also the author of Scienceblind: Why Our Intuitive Theories About the World Are So Often Wrong (Basic Books, 2017).

Keynote 3

Friday August 26th at 11:00, Auditorium

Conceptual change and teaching; focusing on social science and climate education

Keynote speaker :
Cecilia Lundholm, Professor in Educational Science at Stockholm University, Sweden.

Chair: Gertraud Benke

This presentation suggests how conceptual change could play a powerful role in improving teaching that enables young people to take a well-informed stance towards collective (economic and political) action to combat climate change.
I will i) take account of theories of the process of conceptual change, including the warming trend; (ii) build a view of how social science understanding may be related to support for collective action, given insights from theoretical evidence using the theory of Value-Beliefs-Norms for action (Stern, 2000) from social science education, and iii) use the Model of Educational Reconstruction (Duit et al., 2012) to highlight some important implications for research and teaching in this important topic.

Biography:
Cecilia Lundholm's interests concern conceptual change and instruction in the social sciences (civics, economics and political science) and climate, environmental and geography education.
She is also interested in climate change education and the role of social science knowledge for environmental policy support in relation to climate change - that is, large scale collective action problems - and for developing agency and hope among students.

ABSTRACTS OF THE PAPERS AND POSTERS PRESENTED

On the following pages you will find abstracts of all papers and posters to be presented.

Each paper and poster is labeled with an abstract number

Abstract #

mentioned on the program chart in your conference bag.

PAPER SESSION 1 Conceptual Change in Teacher Education

Wednesday 24 August 2022 16:30 – 18:00
Room: B0.42 Chair: Terhi Mäntylä

Abstract 1

The effect of pedagogical training on university teachers' professional vision and conceptual change

Neea Heinonen (neea.j.heinonen@helsinki.fi), University of Helsinki, Finland
Ilona Södervik (ilona.sodervik@helsinki.fi), University of Helsinki, Finland

Professional vision, i.e. teachers' ability to notice and interpret significant classroom incidents based on their conceptions of teaching and learning, is an important part of teachers' pedagogical expertise. However, theories of conceptual change have not been widely applied in higher education teacher expertise research, particularly related to professional vision. In this study, we investigate university teachers' (mis)conceptions of teaching and learning in relation to their professional vision utilizing a pretest-posttest design with a 5 ECTS pedagogical training in between. A total of 32 university teachers participated in the pretest and answered 27 Likert scale questions, 7 misconception items with open-ended explanations and watched a short video of teaching-learning situation. Participants' eye movements were recorded during the video watching and after this, a stimulated retrospective recall interview was conducted. The preliminary results show that in the pretest, teachers focused particularly on students' action in the classroom video. Additionally, university teachers had several misconceptions related to teaching and learning before the course and they decreased statistically significantly during the course. The study acknowledges the importance of understanding how teachers' (mis)conceptions influence their interpretation of classroom events. Recognizing and understanding university teachers' (mis)conceptions related to pedagogical theories is crucial in supporting teachers' expertise development. Thus, this study provides more insights on the development of university teachers' pedagogical expertise, and the results can be used to advance teacher education on a higher education context.

Abstract 2

Changing the conceptualization of teaching of retrained student teachers through attentive teaching

Yaron Schur (schurfa@netvision.net.il), David Yellin Teachers College, Israel
Ainat Guberman (ainatgub@gmail.com), David Yellin Academic College, Israel

Utilizing “Attentive Teaching” to change student teachers' conceptualization of teaching and learning Student teachers often have traditional conceptualization of teaching and learning (Grossman et al., 2009). This study aimed to change retrained student teachers' conceptualization of teaching into student centered one. The Attentive Teaching method (Author, 2019) was utilized. Attentive Teaching is a dialogical teaching method that claims that teaching involves forming connections between students' worlds and learnt contents. Gradual conceptual changes are achieved through group discussions, multiple encounters with the learnt contents from different (sometimes unexpected) perspectives and mediation. Students' learning processes are expressed through drawings and their explanations throughout the teaching/learning course. Ten students (8 females) participated. They drew what teaching was in their opinion in the beginning and end of a course on Attentive Teaching, and explained their drawings verbally. The findings reveal that in the beginning student teachers expressed difficulties in communicating with their pupils and focused on content they tried to "deliver". In the end of the course they emphasized the importance of listening to each pupil's point of view, multi-directional communication between peers and the teacher and the connection formed between pupils' individual worlds and the learnt contents. The students experienced the advantages of Attentive Teaching, understood its principles and their conceptualization of teaching changed. The paper concludes with the advantages of drawings as means of conceptualization and demonstration of conceptual change.

Abstract 3

Tracking changes in explanations - Pre-service teachers' conceptual development in DC-circuit tasks

Terhi Mäntylä (terhi.k.mantyla@jyu.fi), University of Jyväskylä, Finland
Tommi Kokkonen (tommi.p.kokkonen@jyu.fi), University of Jyväskylä, Finland
Anna-Leena Kähkönen (anna-leena.m.kahkonen@jyu.fi), University of Jyväskylä, Finland

The scientific explanations are at the core understanding science. However, the concept of scientific explanation itself is not unambiguous. In this descriptive study, we approach the pre-service teachers' explanations from the perspective of conceptual structures embedded in them and how their changes reflect pre-service teachers' conceptual development. The context of the study was sessions of predict-observe-explain-tasks about the brightnesses of the bulbs in DC-circuits. The data consist four 3-member groups videoed task sessions. Altogether 12 individuals' explanations were analyzed through content analysis. These explanations were categorized according to their explanatory power. Further, the explanatory power was applied to illustrate pre-service teachers' conceptual development. The results show that this kind of descriptive approach to explanatory power of explanations can reveal interesting features of the explanations and conceptual development processes.

PAPER SESSION 2 Conceptual Change in Physics Education

Wednesday 24 August 2022 16:30 – 18:00
Room: Auditorium Chair: Wim van Dooren

Abstract 4

Coming to Discern the Appropriateness of Exponential Models in Contextual Situations

Elahe Allahyari (elahe.allahyari@wmich.edu), Western Michigan University, United States

Coming to discern appropriateness of exponential model in contextual situations Abstract. Exponential function is one of important concepts in advanced mathematics. Teaching in a developmental mathematics program illustrates that students appear to have a deep understanding of exponentiation in context-dependent problems, rather than the already structured symbolic form of exponential models. This led to the question of what type of contexts could promote more appropriate use of exponential or make profitable conflicts (disequilibrium) to transfer from context to abstraction. This work presents Microgenetic Analysis of Learning (MAL) of two undergraduate students coming to perceive and understanding of exponentiation across a series of word problems. Analysis of the data of this work supports the importance of context-dependent problems in developing conceptual understanding of exponential situations. The analysis is guided by the Transfer-in-Pieces perspective (Wagner, 2006), which emphasizes the role of multiple instantiations of a concept across multiple contexts as learners construct their understanding. Three episodes of in-depth interviews are analyzed and reveal different patterns of knowledge activation and use depending on context. In particular, in a context in which recursiveness was salient, the participants reasoned unproblematically with an exponential model. However, in the next episode, they reverted to their prior reasoning patterns using proportional models. The results suggest that contexts that embody the notion of recursiveness may help students activate and use appropriate knowledge resources related to exponential models.

This paper is presented via an online link

Abstract 5

Students' mental models on the Apparent Motion of the Sun and stars.

Mieke De Cock (mieke.decock@kuleuven.be), KU Leuven - Department of Physics and Astronomy, Belgium
Hans Bekaert (Hans.bekaert@kuleuven.Be), KU Leuven - Department of Physics and Astronomy, Belgium
Wim Van Dooren (wim.vandooren@ped.kuleuven.be), KU Leuven, Belgium
Hans Van Winckel (hans.vanwinckel@kuleuven.be), KU Leuven, Belgium
An Steegen (an.steegen@kuleuven.be), KU Leuven, Belgium

Although we see the Sun rise and set every day and we observe the stars during the night, research shows that many people have difficulty describing and explaining the apparent motions of the Sun and stars (see e.g., references in Bekaert, Van Winckel, Van Dooren, Steegen, & De Cock, 2020). To design activities that support learning, we thus need insight in how students explain these apparent motions and whether these explanations are based on specific mental models (Corpuz & Rebello, 2011). We therefore designed a test instrument that systematically probes different aspects of these apparent motions (Bekaert et al., 2020). We administered the test with 410 Belgian students (age 16-17 years). Based on their written explanations, we developed a classification scheme that, together with a latent class analysis based on the multiple-choice answers, allowed us to identify several mental models. While we argue for the existence of these mental models based on our data, we also see that many students do not answer the different questions about Sun and stars coherently.

References

Bekaert, H., Winckel, H. V., Dooren, W. V., Steegen, A., & Cock, M. D. (2020, November). Design and validation of an instrument to test students' understanding of the apparent motion of the Sun and stars. *Physical Review Physics Education Research*, 16, 020135.

Corpuz, E. D., & Rebello, N. S. (2011, July). Investigating students' mental models and knowledge construction of microscopic friction. I. Implications for curriculum design and development. Physical Review Special Topics - *Physics Education Research,* 7, 020102.

Abstract 6

AMoSS-junior - A test instrument on the Apparent Motion of the Sun and stars

Wim Van Dooren (wim.vandooren@ped.kuleuven.be), KU Leuven, Belgium
Mieke De Cock (mieke.decock@kuleuven.be), KU Leuven - Department of Physics and Astro

Many young children, students, and even adults have difficulties to describe and explain the motion of the Sun and stars as we observe them in the sky (Plummer, 2009). However, a good understanding of these apparent motions is essential as a starting point to study more advanced astronomical concepts. Bekaert, Van Winckel, Van Dooren, Steegen and De Cock (2020) developed and validated a dedicated test instrument that allows to systematically map secondary school students' understanding of the Apparent Motion of the Sun and stars (AMoSS test). However, the test instrument does not allow to investigate the understanding in substantially younger students. In this contribution, we report on the development and validation of an instrument based on the AMoSS test, specifically aimed at 10-12-year-old students. We first conducted interviews in the style of Plummer (2009), and used the outcomes to design a new written test for 10-12-year-olds (AMoSS-junior), mimicking the original AMoSS test as closely as possible. We report on the design process and provide evidence for the new instrument's validity and reliability.

References

Bekaert, H., Van Winckel, H., Van Dooren, W., Steegen, A., & De Cock, M.(2020). Design and validation of an instrument to test students' understanding of the apparent motion of the Sun and stars. *Physical Review Physics Education Research*, 16, 020135.
Plummer, J. D. (2009). A Cross-age Study of Children's Knowledge of Apparent Celestial Motion. *International Journal of Science Education*, 31, 1571–1605.

PAPER SESSION 3 Conceptual Change in Math Education

Thursday 25 August 2022 9:30 – 10:30
Room: B0.42 Chair: Konstantinos Christou

Abstract 7

Considering conceptual change as a source for errors when comparing data sets with boxplots

Martin Abt (martin.abt@ph-freiburg.de), Pädagogische Hochschule Freiburg, Germany
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One main reason for errors when comparing data sets with boxplots is the counterintuitive meaning of the box area: it is inversely related to the distribution's density and not proportionally related to the represented part of the sample—as in other representations. We conducted a pilot study (N=38) to investigate whether the occurrence of an area bias depends on incomplete conceptual change. Via cluster analysis we identified a first group, who showed no area bias, a second group who systematically answered with area bias, and a third group with intermediate knowledge—answering specific items (i.e., when comparing the salient median led to the correct answer) without area bias. The results are in line with our hypotheses: the first group, in contrast to the second group, fully completed the conceptual change necessary, and the incomplete conceptual change in the third group prevents the area bias only in certain tasks. We therefore consider conceptual change theory appropriate to explain the area bias in comparing data sets with boxplots.

References

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Abstract 8

What is the sign of the numbers the students tend to associate with the algebraic expressions?

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This study focused on testing students' numbers associations with algebraic expressions that have a salient positive (e.g. x+3) or negative phenomenal sign (e.g. -x-3), and also when the expression does not have a salient phenomenal sign (e.g. x-3). Due to students' tendency to apply their initial natural number knowledge when this does not apply (named as the natural number bias phenomenon), students tend to think that variables stand only for natural numbers. As a byproduct, it is hypothesized, they would tend to think that positive-like algebraic expressions stand for positive numbers only, and negative-like expressions stand only for negative numbers. The participants (178 students from 7th to 9th grade) were given a questionnaire and were asked to agree or disagree with each of the 36 statements about the numbers (either positive or negative) that were assigned to expressions. The expressions were: positive-like (e.g. 8x+4), where only positive signed components were involved; negative-like (e.g. -x-4), where only negative signed components involved; sign-neutral (e.g. 8x-4), where positive together with negative signed components were involved. Considering the tasks with algebraic expressions that had a salient positive or negative phenomenal sign, preliminary results supported the main hypothesis of the study, showing that students performed significantly higher in the tasks that were in-line with their intuitions that only numbers with the same sign as the phenomenal sign of each expression may be associated with this expression, than in the tasks that were against this belief. Responses to sign-neutral tasks will also be presented.

PAPER SESSION 4 Conceptual Change in Science Education

Thursday 25 August 2022 9:00 – 10:30
Room: Auditorium Chair: Gertraud Benke

Abstract 9

Students' conceptions of photosynthesis and plant respiration: A person oriented approach

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Jake McMullen (jamcmu@utu.fi), University of Turku, Finland
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Photosynthesis is one of the most important biological phenomenon. Without a proper understanding of this concept, it is impossible to realize the crucial role of plants to the planet and all life forms. However, there are many misconceptions related to photosynthesis in all age groups. There is a need not only to identify these misconceptions, but to characterize patterns of learning too. Despite this, many studies ignore to pay attention to the heterogeneity among learners. More than 1000 Lithuanian students from 7 to 11 grades answered to 13 two-tier type questions, dedicated to eight sub-topics about photosynthesis and plant respiration. In the first analysis students answers were classified in scientific concepts, synthetic models and misconceptions. The latent profiles analysis shows that besides high and low performing students there are students in transition, which is characterized by low misconceptions, high synthetic models and average level of scientific concepts. According to the latent class analysis there was a group with high performance in all and another group with low performance in all tasks. Between them there were groups with high performance in tasks not so fundamental for conceptual understanding but low performance in tasks requiring deep conceptual change.

Abstract
10

Diagnosing and Promoting the Understanding of Chemical Bonding Theory

Adrian Zwyssig (adrian.zwyssig@gess.ethz.ch), ETH Zurich - Research on Learning and Instruction, Switzerland

Is a salt crystal comprised of molecules? 39 % of science undergraduates falsely assume so as they overgeneralize the covalent bonding type. Overgeneralization is a major challenge in science education. Typically, students neglect the differences between the three types of chemical bonds, i.e. covalent, ionic and metallic bonds. This was confirmed by assessing undergraduates' knowledge about bonding theory before attending lectures at a Swiss university (N = 1946). This assessment revealed the prevalence of various misconceptions such as the overgeneralization of the model of covalent bonding, as well as uncertainties concerning the differences between chemical bonds and intermolecular forces. Thus, the question arises, how can we promote a better understanding of chemical bonding theory? Comparing and contrasting activities have been proven effective for learners to keep the differences between similar concepts in mind (Alfieri, Nokes-Malach, & Schunn, 2013). Therefore, I designed teaching materials (24 lessons) containing multiple comparing and contrasting activities, introducing the three types of chemical bonds simultaneously. In a pre- and post-test classroom intervention study at various Swiss gymnasiums (N = 121, grade 10) the materials' effectiveness was evaluated. Comparing and contrasting activities fostered conceptual understanding in a sustainable manner and were better suited to promote conceptual change about chemical bonding theory than the conventional sequential introduction of the different bonding types.

Reference

Alfieri, L., Nokes-Malach, T. J., & Schunn, C. D. (2013). Learning Through Case Comparisons: A Meta-Analytic Review. Educational Psychologist, 48(2), 87-113.

Abstract
11

Elementary students' understanding of climate change

Gertraud Benke (Gertraud.Benke@aau.at) Alpen-Adria University, Klagenfurt, Austria

Understanding climate change and societal options to counter climate change are the future central issues of our time. For schools and classrooms, the question arises as to when with which topics and how an examination of this issue can be meaningfully begun. Answering this question requires knowledge about what children bring to the table at what age and what they can understand according to their level of cognitive development. Numerous studies focus on prospective teachers' understanding of climate change. (e.g., Breslyn & McGinnis, 2019) In contrast, comparatively few studies focus on children's and adolescents' understanding; almost exclusively, these studies work with students who are at least 6th graders.

This paper investigates the knowledge and understanding of 3rd-grade elementary school students on the topic of climate change. As part of a teacher education project, teachers in four different classes (urban and rural Austria) developed teaching units on climate change. Thirty-one students were interviewed about their ideas on climate change, the greenhouse effect, climate, and weather. Students' conceptual understanding was analyzed using concept maps. As expected for the age group, the ideas proved to be fragmented and conflated with the topic of environmental protection. Despite a complete lack of understanding of climate, the children have convictions about climate change and, after the lessons, also about the greenhouse effect.

Reference

Breslyn, W., & McGinnis, J. R. (2019). Investigating Preservice Elementary Science Teachers' Understanding of Climate Change from a Computational Thinking Systems Perspective. *EURASIA Journal of Mathematics, Science and Technology Education*, *15*(6). https://doi.org/10.29333/ejmste/103566

Invited Symposium 1

Supporting learners' conceptual change in mathematics: The role of teachers

Thursday 25 August 2022 14:30 – 16:30

Room: B0. 42 Chair: Andreas Obersteiner Discussant: Stella Vosniadou

Symposium Abstract 12

Learning of mathematics often requires conceptual change (Vamvakoussi, Vosniadou, & Van Dooren, 2013). Because learners often struggle to accomplish conceptual change without specific support, teachers play an important role in facilitating learners' conceptual change. This symposium focusses on the role of teachers. Specifically, the four papers address factors on different levels that influence (preservice) teachers' behaviour relevant to learners' conceptual change in the domain of mathematics. Xenia Vamvakoussi addresses contextual factors and studies issues of designing curricula, which are often the basis of what teachers do in the classroom. The other three studies focus on preservice teachers' cognitive and affective variables that might contribute to the actions they perform to promote conceptual change. Christian Schons and colleagues study preservice teachers' ability to identify students' misconceptions, which is a basis for instructional decisions, in a digital simulation. Emke Op 't Eynde and colleagues look at (preservice) preschool teachers' knowledge and beliefs in association with their questioning behavior during shared book reading to support children's mathematical learning. Jake McMullen asks how pre-service teachers' epistemic beliefs about mathematics are related to their self-efficacy and teaching flexibility.
Stella Vosniadou, a leading expert in the field of conceptual change, will discuss the four papers.

Reference

Vamvakoussi, X., Vosniadou, S., & Van Dooren, W. (2013). The framework theory approach applied to mathematics learning. In S. Vosniadou (Ed.) *International handbook of research on conceptual change*. Routledge.

Anticipating the problem of conceptual change in the development of rational number concepts: Implications for curricular design

Xenia Vamvakoussi, University of Ioannina

Conceptual change research has amply documented that a major source of difficulty in the learning of rational numbers is the transfer of inappropriate prior natural number knowledge. In addition, rational number is a complex concept, interconnected with a multitude of other concepts and processes that are grounded in multiplicative relations. Early informal and formal learning experiences typically pertain to natural numbers and additive relations in the context of discrete quantity. Instruction capitalizes on such experiences to introduce, for example, multiplication as "repeated addition" and fraction as "part of a whole" in discretized contexts that allow for the use of single-unit counting schemes and additive reasoning. Such approaches initially facilitate but eventually impede students' understandings of multiplicative situations, particularly when fractions are involved. Taking a prospective-developmental approach to mathematics instruction, I will present the rationale and empirical findings of an ongoing topic-specific design research study that aims at developing a program of activities to support early multiplicative reasoning. The program a) addresses discrete and continuous quantities in a unified manner, b) grounds multiplicative relations on measurement, and c) provides linguistic tools, specifically, terms for multiples and submultiples. The latter leads to the introduction of fraction names to express multiplicative quantitative relations, building a meaning for fraction less conducive to transfer of inappropriate natural number knowledge. The first and second enactment of the program with a limited number of kindergarten and Grade 1 children indicate that the program is within young children's range of abilities and substantially increases their multiplicative reasoning competences.

Identifying primary school students' misconceptions in a digital simulation

Christian Schons, Andreas Obersteiner, Frank Fischer, Kristina Reiss

Students' systematic errors and misconceptions in mathematics are often robust. Therefore, it is important that teachers are able to identify them in order to provide targeted support for conceptual change. One way of identifying students' errors and misconceptions is to assign them written tasks that have the potential to reveal specific errors. Research suggests that teachers often struggle with identifying relevant task features, and we do not well understand which tasks teachers actually select for assessment purposes.

We analysed *N* = 80 pre-service primary school teachers' task selections during assessments in a digital simulation. Participants had to identify virtual primary students' misconceptions in the domain of numbers. To that end, they selected a task from a portfolio, assigned it to a virtual student, and then received the student's solution. Participants could repeat this process until they came to a conclusion. The tasks in the portfolio did or did not have the diagnostic potential to reveal specific student errors.
There were great individual differences in the total number and the quality of tasks participants selected for their assessments. We found that the *quality* of selected tasks (i.e., their potential to reveal a specific error) but not the total *number* of selected tasks was related to assessment accuracy.
The results support the idea that tasks need to be selected carefully when assessing students' misconceptions in specific domain. On a more general note, the results show that log data from digital simulations can yield insights into teachers' processes during task-based assessments of students' errors.

Exploring pre-service teachers' beliefs about mathematics: A conceptual change approach

Jake McMullen, University of Turku, Finland

Pre-service teachers' mathematical beliefs are expected to affect later teaching practice. As such, one goal of teacher training programs is to foster appropriate beliefs about the nature of mathematics, mathematics instructional practices, and students' abilities with mathematics. Teachers' beliefs may collectively develop into a consistent belief system that involves, for instance, core beliefs with clusters of related beliefs held in close connection. Therefore, the systemic nature of these beliefs may require substantial conceptual change to be altered during pre-service training. To this end, we asked 93 pre-service classroom teachers about their mathematical beliefs using 12 items from the TEDS-M international questionnaire on mathematics teaching and an additional 6 items that specifically addressed issues of mathematical flexibility. Based on confirmatory factor analysis, four scales emerged. Notably, pre-service teachers' beliefs about the nature of mathematics instruction in general and instruction for mathematical flexibility appeared distinct. As well, the importance of mathematics for solving everyday problems emerged as a critical feature of teachers' beliefs about the nature of mathematics. Based on the resulting factor scores, initial Latent Profile Analysis revealed a five profile model of mostly coherent belief systems. Results will be examined from the perspective of conceptual change in teacher's beliefs.

Asking questions during shared book reading to support children's mathematical learning

Emke Op 't Eynde[1], Fien Depaepe[2], Lieven Verschaffel[1], Wim Van Den Noortgate[2], and Joke Torbeyns[1]
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Shared book reading (SBR) is an effective activity to stimulate children's early language and literacy development (Mol et al., 2008). The questions adult readers formulate during this activity were shown pivotal for its effectiveness (Walsh & Hodge, 2016). As insights into these questions in the domain of mathematics are scarce, we aimed to analyze the mathematical questions preschool teachers formulate during SBR to engage preschoolers in mathematical thinking. We focused on the chance of formulating a mathematical question and the level of abstraction of mathematical questions, in association with teachers' professional dispositions and type of picture book. Participants were 274 (preservice) preschool teachers. The chance of formulating a mathematical question and the level of abstraction of these questions were measured using a video-based instrument. We distinguished between mathematical and non-mathematical picture books. We additionally assessed teachers' (1) mathematical content knowledge (MCK), (2) mathematical pedagogical content knowledge (MPCK), and (3) beliefs about mathematics, using three online questionnaires. Results revealed that preschool teachers' MPCK and the type of picture book were associated with both the chance of formulating a mathematical question and the level of abstraction of these questions. Teachers' MCK contributed to the level of abstraction of the mathematical questions. Our findings point to the importance of both the type of picture book used and teachers' professional dispositions to provoke mathematical interaction during SBR. We discuss the theoretical and practical implications of these findings and point to timely avenues for future studies.

Symposium 2

Environmental challenges and education - focusing on conceptual change and the social sciences

Thursday 25 August 2022 14:30 – 16:30

Room: Auditorium Chair: Cecilia Lundholm

Symposium Abstract 13

Knowledge of economic, political and legislative aspects on solutions to mitigate climate change and other environmental problems is important as it informs which choices merit action. This symposium seeks to meet three educational challenges on environmental and climate change: i) education has privileged natural science subjects; ii) has not focused on understanding of interconnectedness between society and nature, and iii) has not addressed participation, action and hope (Levy and Zint, 2014; Li and Monroe 2019). The climate change concerns of modern youth are manifested in the Greta Thunberg movement #FridaysForFuture and the largest Global Climate Strike in history was led and organized by youth, demonstrating their concern about the impact of climate on their futures (Krieger, 2020). The symposium presents research on students' conceptions of both causes to environmental problems and solutions. The later is important as research shows that knowledge of solutions (individual and national level) develops hope (Li and Monroe 2019). Two of the papers present findings showing students' conception of solutions that concern behaviour in various ways. Regulation, by the state, is suggested and is seen as decreasing production causing climate change or environmental damage. However, along with other solutions, students' show limited understanding of how environmental policies and measures actually affect the market, and change consumer behaviour. The third paper presents students' conceptions of causes to global environmental change, concluding that students have an incorrect understanding that needs to be addressed in instruction, which is a necessary prerequisite for understanding ways of solving the problems.

Collective action as climate change solutions - students' conceptions of environmental policies

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Cecilia Lundholm (cecilia.lundholm@su.se), Stockholm University, Sweden

Climate change can be seen as a social dilemma and thereby a large-scale collective action problem which increases the demand for government intervention to coordinate behaviour. However, such interventions depend on citizens' knowledge and support for pro environmental policies and are thus crucial in democratic societies. In this study we explore students' conceptions of policies that are often used to mitigate greenhouse emissions such as climate taxes, subsidies and regulations, and their judgements of these. We used an interview format focussing on of how various policy measures work, and change market prices. Results show students' understandings of economic measures and regulations. Practical implications of findings are discussed from a perspective of designing social science education that supports student learning.

Conceptual change and explanations to the Attitude-Behaviour Gap in relation to sustainable fashion

Carmela Aprea (aprea@bwl.uni-mannheim.de), University of Mannheim, Germany

As with other commodities, consumers' growing awareness of the need for sustainable fashion does often not translate into corresponding consumption behaviour. This phenomenon, commonly known as the attitude-behaviour gap, seems to be specifically prevalent among the 20–30-year-olds, i.e., the so-called Generation Y. However, while the phenomenon is widely known, the reasons for it are not yet fully understood. The study presented here assumes that a conceptual change perspective is fruitful to further investigate this phenomenon, mainly because it addresses factors that have not been considered in prior research. On this basis, the study explores by means of semi-structured interviews (n = 14) and subsequent thematic analyses how well young adults understand issues of sustainable fashion production and consumption, how they view their own influence and responsibility, and which emotional affinity they have in relation to sustainable fashion. The analysis showed that respondents were aware of the detrimental social effects of non-sustainable fashion, whereas negative impacts on the environment, including excessive waste, were less often considered. In addition, most respondents felt that their behaviour had no significant impact and assigned the main responsibility for sustainability in the fashion industry to the state, which is expected to impose regulations. Furthermore, nearly all participants expressed

regrets for those who suffer from the fast fashion industry. The conceptual change perspective made it possible to look at previously unexplored aspects of the attitude-behaviour gap in Gen Y, and further research and preliminary practical implications are suggested.

What Causes Global Environmental Change? Students` Conceptions About Economic And Population Growth

Irene Lampert (irene.lampert@phlu.ch), University of Zurich; Teacher University Lucerne, Switzerland

The planetary boundary framework is a science-based approach to describe global earth system changes. It identifies nine planetary boundaries and has become an important tool for political decision-making. In this paper, we explored how scientists` and students` conceptualized the planetary framework and global environmental change and developed instructional guidelines based on the comparison of their conceptions. We collected data from 42 German-speaking Swiss high-school students and analysed students` conceptions. Also, a systematic search process was conducted, and nine scientific publications were analysed focusing on scientists' conceptions of the topic. The results showed that students believed humans had initiated the global environmental changes, though they did not have the ability to limit them, and considered humanity and associated global population growth to be the main causes of global environmental changes. Scientists, on the other hand, deemed the expanse of natural resources consumed by rich countries in their economic pursuits as the most critical factor in environmental degradation, and not the Earth's population. Based on our findings, we propose instructional guidelines to plan lessons relevant to the topic of understanding the drivers for global environmental change.

Poster Session

Thursday 25 August 2022 17:00 – 18:00 Room: Atrium

Abstract 14

Learning about the internet: work in progress poster

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Anna Yaghobová (yaghobova@ksvi.mff.cuni.cz), Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic
Anna Drobná (drobna@ksvi.mff.cuni.cz), Faculty of Education & Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic
Kateřina Zábrodská (katerina.zabrodska@ff.cuni.cz), Institute of Psychology, Czech Academy of Sciences, Prague, Czech Republic

Little is known about what preconceptions primary school children and teachers have about the internet's structure and function, which of these preconceptions complicate learning about these topics, and how to boost children's and teachers' understanding. We have initiated a research project, in which we examine what preconceptions children (and their teachers) about the internet have, what they can learn about it, and where learning difficulties lie. This poster presents the overall project's design and preliminary findings from an interview study examining preconceptions among 28 5- and 28 9-graders and 39 in-service teachers with limited experience in teaching computer science. Preliminary analysis suggests that participants have numerous preconceptions; some of these are normatively correct and many incorrect. The preconceptions include, among others, the idea that the internet has headquarters; that one only needs a satellite to communicate between two computers; or that the "internet signal" works in the same way as the television signal. So far, it appears that it will be possible to organize our findings within DiSessa's 'knowledge in pieces' framework, particularly its more recent expansion working with so-called 'explanatory primitives'. Altogether, our project enhances previous research on understanding the internet by aiming to produce fine-grained description of preconceptions, to include teachers' preconceptions, and, crucially, to examine which preconceptions are resistant to change and which conceptions can be acquired by children/teachers easily. This teaching aspect is the most substantial innovation of our project.

Abstract
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How Executive Functions and Motivation Contributes to Conceptual Change About Density

Tamer Said (thss2@cam.ac.uk), University of Cambridge, UK, United Kingdom

Abstract The current study examined the relationship between cognitive (executive functions) and non-cognitive (motivational) elements on conceptual change. A sample of 426 students (M age = 12.5) in Egypt received an intervention that targeted key misconceptions about density. The relationship of executive functions and motivational variables as predictors of conceptual gains was analysed using structural equation modelling analysis. The findings indicate that executive functions predicted students baseline achievement (ß = .18, p < .05) in the density questionnaire but not their conceptual gains. On the other hand, motivational elements showed to be key predictors of their conceptual gains (ß = .15, p < .05) but not their prior achievement. On the other hand, adopting a performance goal orientation negatively predicted students' conceptual gains (ß = -.18, p < .05).The study also highlights the importance of motivational elements in the context of conceptual change and alternating misconceptions. Implications for teaching and curriculum design are discussed. This study contributes to a more developed understanding of the cognitive and non-cognitive factors that could facilitate a conceptual change process. Keywords: Conceptual change, executive functions, motivation, performance goals.

Abstract
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The impact of prior knowledge and intelligence on understanding the physical field concept

Christian Thurn (christian.thurn@ifv.gess.ethz.ch), ETH Zurich, Switzerland
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Ralph Schumacher (ralph.schumacher@ifv.gess.ethz.ch), ETH Zürich MINT Learning Center, Switzerland
Elsbeth Stern (elsbeth.stern@ifv.gess.ethz.ch), ETH Zurich - Research on Learning and Instruction, Switzerland

How intelligence and prior knowledge contribute to conceptual understanding in interaction with each other remains an ongoing subject of research. We investigated the effects of individual differences in intelligence on promoting conceptual understanding in physics depending on whether or not participants had been supported in acquiring prior knowledge. In a preregistered study, 119 secondary school students received extra-curricular instruction on the topic of magnetic, electric and gravitational fields in a quasi-experimental pre-posttest design. We investigated two groups of students: the “magnetism group” had undergone a teaching unit in primary school on the topic of magnetism, which is related to the field concept. The control group did not undergo this prior teaching unit on magnetism. The extra-curricular instruction on the field concept, however, was self-contained and did not directly build on the prior teaching unit on magnetism. The results suggest that prior knowledge in magnetism provides sustainable benefits in achievement on the physical field concept. The magnetism group scored higher in the pre- and the posttest. However, the control group showed larger learning gains. Regarding the relation of prior knowledge and intelligence, intelligence unveiled its effects particularly in the magnetism group. As shown in a latent mediation model, there were indirect effects of intelligence via prior knowledge in this group, supporting the investment theory of intelligence.

Abstract
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Students' conceptions of pricing and conceptual change of students in economic education

Katharina Bushyla (bushyla@em.uni-frankfurt.de), Goethe-Universität Frankfurt, Germany

The present study focuses on the change in students' conceptions of pricing in economic and business education. In the context of an intervention study, the cognitive conflict strategy is used to promote conceptual change. The results of previous studies, which identify possible reasons for the lack of effectiveness of cognitive conflict strategy (Limón, 2001), are taken into account in this study. First, interviews will be used to determine the students' conceptions of pricing. Based on this, we are planning a lesson, which implements the cognitive conflict strategy. We decided for a quasi-experimental design with an experimental group (cognitive conflict group) and a control group. Furthermore, we used a pretest-intervention-posttest design and one follow-up-assessment. Conceptual change will be measured by using concept maps.

Abstract
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The connection of self-efficacy expectations and teaching learning beliefs

Evelyn Kobler (evelyn.kobler@phsalzburg.at), University of Education Salzburg Stefan Zweig, Austria

The presentation aims to contribute to the debate on competence-based professionalization of early childhood teachers. It deals with the characteristics and interaction of self-efficacy expectations and teaching-learning beliefs among teachers in the educational domain of Natural Sciences. An instrument for determining domain-specific self-efficacy expectations was developed. Beliefs were assessed for the three dimensions instructivist, constructivist and co-constructivist, using a standardized instrument. In addition, the interest of professionals in the educational domain of Natural Sciences, their general self-efficacy expectations as well as their professional experience and science-related further and continuing education were determined. The sample consists of teachers (n = 252) who work as group leaders in elementary educational institutions in Austria. The data were collected by means of online questionnaires at one measurement point. In contrast to the initial assumptions, the results show that the examined early childhood education teachers have high self-efficacy beliefs in early science education within the two dimensions of child-centered pedagogical action and methodology and didactics. The results on domain-specific teaching-learning beliefs indicate a high level of agreement with co-constructivist and constructivist teaching-learning beliefs, though instructive learning theory beliefs were not rejected. Regarding the interaction of the dispositional competence facets, significant associations between domain-specific interest, self-efficacy and teaching-learning beliefs were found in this sample. Furthermore, significant effects of self-efficacy on instructivist and constructivist teaching-learning beliefs could be observed. Finally, the study indicates that further training can only predict interest in the educational domain of Natural Sciences and work experience exerts no effect on the study variables.

PAPER SESSION 5 Collaboration and Conceptual Change

Friday 26 August 2022 9:00 – 10:30
Room: Auditorium Chair: Shulamit Kapon

Abstract 19

Interpreting conceptual structure negotiations through acoustic voice analysis

Anna-Leena Kähkönen (anna-leena.m.kahkonen@jyu.fi), University of Jyväskylä, Finland
Kati Järvinen (kati.h.jarvinen@jyu.fi), University of Jyväskylä, Finland
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Conceptual development is difficult to study dynamically. This study shows one method combining acoustic analysis and content analysis to make interpretations of a learning dialogue between university students. The recordings are used to study both fundamental frequency F0 and sound pressure level SPL as well as transcribed for expressed conceptual structures and connections. Initial results show the discussion includes mirroring effects during the negotiation of models, and that the models are very resistant to change. The interplay of acoustic and content analysis is fruitful, and applicable even on classroom recordings. The results may also help teachers interpret discussions in their classroom. Work on a complete dialogue will be shown in the talk. KEYWORDS: acoustic analysis, dynamic conceptual change, science teacher education

Abstract
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Argumentation and concept development in higher education

Ingrid González (igonzalez@userena.cl), Universidad Alberto Hurtado, Chile
Antonia Larrain (alarrain@uahurtado.cl), Universidad Alberto Hurtado, Chile

There is evidence that supports the important role that argumentative practice has on concept learning of school students (Felton et al., 2009; Larrain et al., 2018). However, evidence about such role in higher education is still scarce. If we consider that, according to Vygotsky, concepts are processes of generalization that are continually developed (micro and ontogenetically), we ask ourselves, beyond the existing evidence for teenagers and children, what do we know about the role of argumentative practice and concept learning in university students? Evidence is not enough nor is it clear about the role of argumentative practice for disciplinary concept learning of higher education students. On this matter, we pose that it is important to engage in theoretical thinking about the role that argumentative practice would have on the learning of a specific discipline. To do this, a dialectic view of the nature of disciplinary knowledge is adopted, and from there we reflect upon why, particularly in the context of higher education, argumentation could be a tool to develop conceptual thinking. We think that, from a Vygotskian notion of concepts, placing university students in the position where they have to argue, counterargue, and answer their peers' questions can help to build, explore, and go through the meanings of their specific disciplines. Meanings that are organized dialectically and systematically. Besides, the potential of argumentative practice for concept learning would address the need to foster students' autonomous thinking, allowing them to actively think their disciplinary knowledge instead of reproducing it.

Abstract
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Making Sense of Science in Collaboration

Ada Abes; Technion - Israel Institute of Technology, Israel
Shulamit Kapon, Technion - Israel Institute of Technology, Israel
Haggai Ben Ami (haggai.benami@gmail.com), Technion - Israel Institute of Technology, Israel

How can students collaborate to answer scientific questions? We present a preliminary attempt to model the collaborative construction of an explanation over a short time span. A distributed knowledge system was extended from Sherin et al.'s (2012) individual knowledge systems and its dynamics were investigated at a high temporal resolution. We operationalize and identify shared nodes-fragments of knowledge shared by the collaborators; shared dynamic constructs (SDCs)-temporary knowledge structures developed and decomposed in the process of making sense and shared modes-stable knowledge structures stored in the memory of the distributed cognition. By using regulatory statements that define the relationships between the fragments of knowledge, the analysis captures the evolution of the distributed knowledge system.

PAPER SESSION 6 Theorizing Conceptual Change (part 1)

Friday 26 August 2022 9:00 – 10:30
Room: B0.42 Chair: Ines Langemeyer

Abstract 22

Conceptual conflict between beliefs and experience of learning theories.

Erik Meij (th.meij@windesheim.nl), Windesheim University of Applied Sciences, Netherlands
Anneke Smits (aeh.smits@windesheim.nl), Windesheim University, Netherlands
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A teacher should arguably know about learning theories (LTs) in order to make daily pedagogical decisions. However, little literature exists on the role of LTs in teacher education. To gain more insight, a qualitative study was conducted where eight teacher educators from different programs were interviewed on LTs within their curriculum (author, 2021). LTs were unanimously considered important but huge variation was found in what and how LTs are taught. Space devoted to LTs varied from intensive courses to total absence, and teaching methods from theoretical courses with or without exams to assignments in internships. Textbook contents and boundary conditions seemed to weigh more in these choices than pedagogical considerations. Most remarkable is the difficulty that respondents had with the question whether one can be a good teacher without theory. The question seemed to provoke a conceptual conflict between a bedrock belief that in higher education one should substantiate one's pedagogical choices with theoretical underpinnings on the one hand, and their perceptions that in daily practice such underpinning is rarely authentic on the other. A question of interest is here whether their belief and daily experiences cause a cognitive conflict or that they are grounded on distinct parallel concepts.

Abstract
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Managing Scientific Uncertainty for Conceptual Change: A Theoretical Framework for Productive Struggle in Sense making.

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Researchers have explored the process of conceptual change in order to identify when and with what students may struggle and offered frameworks for how teachers can support the sensemaking process. Utilizing students' scientific uncertainty as a resource for deep learning and conceptual change opportunities has been introduced for productive struggle when engaging in sensemaking of a phenomenon, concept, or issue. However, productively managing the emerging uncertainty is challenging for teachers and students in that they are often frustrated by or ignore the uncertainty during sensemaking. It also remains unclear what drives or obstructs sensemaking when students are learning science concepts, and when the process advances or recedes. This paper aims to suggest a conceptual framework to understand how uncertainty management can facilitate students' sensemaking so that they can experience productive struggle to change and develop their scientific concepts. To develop the framework, this theoretical paper explores sources and types of scientific uncertainty, and how the management of these uncertainties does or does not promote the productiveness of students' struggle during sensemaking. Lastly, a framework is proposed to translate the theoretical constructs into classroom practices.

Abstract
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Is knowledge mainly a representation of the world? Conceptual change theory revisited.

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"According to Karmiloff-Smith's (1992) distinction of declarative and procedural knowledge, the purpose and the use of concepts seems to be mainly representational: They either represent processes (how to manipulate, conduct or effect a process) or states (what really exists or what is accurate). Consequently, conceptual change is about correcting definitions and inter-conceptual relations so that cognitive representations of reality become more realistic or more consistent with a given theoretical framework. A different way of understanding cognition is captured in the framework of second-personal forms of cognition (cf. Schilbach 2013). Instead of assuming that the main function of cognition is to inform the brain of reality and that cognitive activity is about finding representations of reality, a new way of understanding cognition has been elaborated in socio-cultural theory. Tomasello's research gives a good account of the development of human capacities of perspective-taking. Human cognition is particular because of its triadic structure. A child begins to recognize a distinction between the intentional thought of the 'you'-perspective and develops intentional thought in the 'I'-perspective. The triadic moment emerges with cognitive activity that ensures that interacting partners have a common background when they act cooperatively. Conceptual-change approaches can be reinterpreted in the framework of second-personal thought. The paper argues that misunderstandings of scientific concepts belong to certain frameworks derived from interpersonal experiences and social order experiences. Examples that illustrate this will be given. Some examples will be taken from Gaston Bachelard's work on the Formation de l'ésprit scientifique (1938). "

PAPER SESSION 7 Theorizing Conceptual Change (part 2)

Friday 26 August 2022 14:30 – 16:00

Room: Auditorium Chair: Erik Meij

Abstract 25

Exploring the Impact of P-prims as a Reference Model in Developing the Knowledge in Pieces Framework

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This paper reviews a strand of work in one of the most prominent research programs aimed at developing a theory of knowledge and learning: Knowledge in Pieces (KiP; diSessa, 1993; diSessa & Sherin, 1998; diSessa, Sherin & Levin, 2016). With nearly 3000 citations, diSessa's 1993 monograph "Toward an Epistemology of Physics" proposed a novel way to think about the form of intuitive knowledge (phenomenological primitives) and learning processes (as knowledge systems that are tuned towards expertise with experience). The purpose of this review is to elucidate how the p-prim construct has been theoretically generative, beyond its initial scope as a model of intuitive knowledge.

This paper will be presented via a live online link

Abstract
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Lexicons in conceptual change research: Exploration of twelve research papers

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Conceptual change (cc) research tradition is not a single theory, but includes different branches and theoretical models. In these models, somewhat unsystematic use of terminology exists. This study investigates the terminology, lexicons and their overlapping in twelve central scientific articles within cc-research field utilizing a network analysis tool. The articles were selected based on certain criteria representing seminal articles, different cc-branches and reviews and they were published between 1982 and 2018. The study contributes to the discussion about the need of unifying the used terminology, when similar constructs are handled with different terms among the cc-tradition. The study provides a new methodological tool to explore and visualize the occurrence of concepts and inter-relatedness of them among cc-literature. The semantic network analysis reveals similarity in terminology of texts that belong to supposedly same kind of cc-research traditions, and on the other hand, clearly lower similarity between texts in different traditions. The results also show that there has attempts to unify the key-terminology in review articles, but these initiatives have not affected the terminology used texts that belong opposing disciplinary groups. Identifying the overlapping in different models would enable the meaningful unifying of terminology, which again is suggested to be desirable for the future theoretical progress of cc-research.

Keywords: Conceptual change models; Lexicon; Terminology; Network analysis

Abstract
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Descartes's radical model of conceptual change: from childhood prejudices to mechanical science

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"Little has been said regarding the origins of the conceptual change research program. In this paper, I will present René Descartes's Meditations on First Philosophy, published in 1641, as a work containing a conceptual change model. Descartes was very critical of the basis of scholastic philosophy. The main target of his critics was the Aristotelian concept of forms. Forms, according to Aristotle, are structures that have the power to develop themselves. Descartes's project was to replace scholastic natural philosophy by mechanical philosophy. But since Galileo's condemnation in 1632, Descartes considered that Aristotelian forms constituted an active obstacle to the adoption of a mechanistic worldview. For Descartes, forms are merely the results of animistic habits. Children adopt such habits early in their cognitive development, before they are able to exert an evaluative control on the epistemic value of those animistic attributions. Scholastic education simply reinforces those habits. The aim of the First meditation is pedagogical: its aim is to help practice withholding of judgments. Descartes wants readers to be able to stop considering as true ideas that they have the habit of considering so without proper examination. Here, Descartes brings in a pedagogical tool, the evil genius. Its function is to help readers to exert extremely high level of doubt, thus an extreme level of (inhibitory) control on their truth judgments. The interest of Descartes's model lies assuredly in the fact that it shows that conceptual change models can be found well before psychology and science education institutionally appeared."

PAPER SESSION 8 Classroom Teaching

Friday 26 August 2022 14:30 – 16:00
Room: B0.42 Chair: Eric Klopp

Abstract 28

Predicting promotes revision of misconceptions: Evidence from Bayesian models and pupillary surprise

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The presented study investigated the hypothesis that asking learners to generate a prediction before presenting conflicting evidence helps them to revise scientific misconceptions. We tested this hypothesis in a sample of children (n = 94, aged 6–9) and in the domain of water displacement. In the learning phase of a between-subject pretest–posttest–transfer test design, children saw pairs of spheres and either had to generate predictions or post hoc expectancy ratings regarding which sphere displaces more water. We further leveraged behavioral and physiological data (i.e., pupillometry) from the learning phase to capture belief revision as it unfolds continuously, using Bayesian computational modeling. Children in the prediction condition exhibited a stronger improvement in performance from pretest to posttest and scored higher in the transfer test, indicating that generating predictions benefited the revision of misconceptions. At a computational level, this benefit could be captured as more optimal Bayesian learning. At a physiological level, this benefit was reflected in enhanced surprise about conflicting evidence, which was predictive of a successful revision of misconceptions.

Abstract
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Creating questions that support conceptual change via digital outdoor learning tool.

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The process of conceptual change (CC) has been discussed in educational sciences for years (see, for review, Vosniadou, 2013), also methods supporting CC (Yip, 2004; Lucariello & Naff, 2013) are suggested. Even if the topic is widely studied by researchers, teachers often indicate that CC practices are hard to implement in everyday teaching (Gomez-Zwiep, 2008). Digital learning tools are one way to support teachers when implementing CC based teaching but it is important to understand how teachers use digital tools without specific support. In the current study we analyzed which kind of questions (N=3168) teachers construct for their students in a digital outdoor learning tool "Discovery Trail" (https://avastusrada.ee/en) compared to layperson-made questions. For analyzing the questions, we used the model distinguishing cognitively lower-order, higher-order and conceptual change-evoking questions (Yip, 2004). Results show that trails created for educational purposes have more cognitively complex questions compared to non-educational trails. Still, overall less than 10% of all the questions in educational trails were found to be cognitively complex. 60% of educational trails had any cognitively complex open ended question, indicating that educators tend not to use the tool for supporting knowledge construction and conceptual change. Simple recall questions were most common. Solutions are proposed on how to make digital tools more compatible with supporting deep learning goals and how teachers could be guided with the help of the digital tool to avoid creating superficial tasks while using innovative learning tools.

Abstract
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Correcting misconceptions about scientific argumentation by presenting erroneous arguments

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Acquiring scientific argumentation competence is a major goal of higher education study programs, but it is common for students to use erroneous arguments often. In erroneous arguments, scientific evidence is not adequately used to support the claim. From a conceptual change perspective, students have misconceptions of the normative use of scientific evidence for supporting claims. Thus, correcting these misconceptions is advised. These misconceptions can be overcome by comparing erroneous and correct arguments. An instructional approach for such a comparison is learning from advocatory errors. By learning from advocatory errors, students acquire knowledge about argumentation errors and how to avoid them by analyzing argumentation errors made by relevant others. Learning from advocatory errors has been shown to effectively foster students' argumentation competence. However, previous studies have shown that learning from advocatory errors needs instructional support. In this contribution, we compare how two forms of instructional support, elaboration prompts versus testing prompts, perform. In a first condition, instructional support in form of testing prompts was given. In a second condition, elaboration prompts were given. These conditions were compared to an intervention without instructional support. The results indicate that both forms of instructional support foster argumentation competence by learning from advocatory errors. However, there were no differences in the outcome between these two forms of instructional support. Additionally, the results show no gain in argumentation competence in the intervention without instructional support. Again, the result shows that instructional support is necessary when fostering argumentation competence by learning from advocatory errors.

Symposium 3

JURE Symposium: Conceptual Change Research Across Ages

Friday 26 August 2022 16:30 – 18:30

Room: Auditorium Chair: Christian Thurn

Symposium Abstract 31

Conceptual understanding can be challenging for people across life-phases due to (lacking) prior knowledge and misconceptions about science. This JURE symposium sheds light on conceptual change research in different contexts and life-phases. While giving junior researchers the possibility to present their projects and work in progress, it also encompasses completed projects and encourages a constructive discussion of conceptual change research across ages:

In primary school, many countries start to teach basic concepts of computer science. Marco Hartmann presents the development of a tool assessing students' misconceptions about programming. He will discuss some difficulties of applying findings from computer science research with adults to research with children. A pilot study gave insights into some possible misconceptions and heuristics that students used.

Parvaneh Babari investigates different ways of practicing rational number arithmetic among 6th graders. Focusing on two well-documented misconceptions, she checks whether any three practicing approaches can lead to a more adequate mathematical conceptual understanding of rational number arithmetic, particularly to overcome these misconceptions.

Erik Meij examines the strains and difficulties of students entering the chemistry teacher education program at university. By transitioning from their own learning experience at school to the theories about learning they encounter at university, conceptual change about the principles of learning occurs. He presents a newly developed course that tries to facilitate this transition.

Nina Vaupotič examines how adults perceive socio-scientific topics such as nuclear power in informal learning contexts. Specifically, she focuses on laypeople's intellectual humility. Her research shows the importance of science communication to support adults in developing a two-sided perspective and engaging with complex scientific topics in their everyday life.

This JURE symposium will discuss, what the different contexts and life-phases imply for conceptual change research targeting basic and applied research.

Investigating programming misconceptions in primary school students

Marco Hartmann, (marco.hartmann@phsz.ch) PH Schwyz, Goldau, Switzerland

Programming is a relatively recent addition to primary school curricula. To optimize its teaching the concepts and misconceptions of students need to be studied. This project aims to develop an assessment tool to better understand primary school students' misconceptions about programming. The tool focuses on students in grades five and six who have been learning to program in either xLogo or Scratch, two of the most frequently used educational programming environments in Switzerland. In a first pilot study, 57 students completed the Scratch version of the test, and 24 were subsequently interviewed on their thought processes during test completion. Test length (30-40 minutes) and difficulty were adequate. The results show that students were on average able to answer 69% percent of the tasks correctly and about 20 % of answers indicated potential misconceptions in four categories: Sequentiality, Loops, Conditionals, and Superbug. However, the test contained some concepts and commands many students were not familiar with and even some familiar commands proved to be confusing when used in novel scenarios. The interviews showed which heuristics or strategies the students used: Random guessing was uncommon. They often focused on parts of the code that were familiar to them and ignored the rest or they made assumptions about what a particular program was intended to do and simply chose a matching answer. I will also discuss the challenges of transferring findings from misconception research with adults to research with children.

Blocked versus Interleaved practice for rational number arithmetic: "multiplication makes bigger" and "division makes smaller"

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Rational number arithmetic is a central topic in primary and secondary school, but many students have difficulties acquiring an adequate conceptual understanding of this topic. The difficulties particularly emerge when students' prior knowledge about natural numbers conflicts with new information about rational numbers provided in classroom instruction, giving rise to systematic errors. Two instances of such errors are the misconceptions "*multiplication makes bigger*" and "*division makes smaller*", which arise from overgeneralization of principles from natural numbers to rational numbers.

In our study, we investigated whether alternative ways of practicing rational number arithmetic benefits learning rational number arithmetic in general and whether this approach may

specifically circumvent the emergence of the misconceptions mentioned above. Eighty-six 6th graders from seven schools in the German-speaking part of Switzerland participated in this tablet-based intervention study. We contrasted *blocked practice* (n=30) with two variations of interleaved practice: In the *Interleaved I* condition (n=31), first addition and multiplication tasks and then subtraction and division tasks were mixed. In the *Interleaved II* condition (n=25), arithmetic tasks for all four operations were mixed.
Our results show an overall significant improvement in all experimental conditions, but no advantage of interleaved practice. We did not observe a significant positive effect on overcoming the two specific misconceptions either, even though some patterns of systematic misconceptions for multiplication decreased over time.

From learning to understanding chemistry: A conceptual change approach at the beginning of teacher education

Erik Meij (th.meij@windesheim.nl), Windesheim University, Zwolle, Netherlands

Students who enter chemistry teacher education at the age of 17 already have a biography of education behind them. Hence, they have developed durable images, concepts and beliefs about education, and they have epistemological beliefs about their own, often overrated chemistry knowledge.
At university, they are confronted with two new insights: Firstly, by acquiring theoretical basics of learning they discover that education and learning are separable concepts to be studied, and secondly, that their understanding of chemistry appears to be flaw. In addition, the concepts taught at university hardly match their personal experience from chemistry education in their own school time, when they had mostly learned facts and rules. From a conceptual change perspective, it is quite challenging for them to reorganize existing and new knowledge as they have to start from a belief system rooted in a rich network of experiences.

Usually, the teacher training curriculum in the Netherlands first offers learning theories and teaching models by a deductive approach. At the age of 17, however, the transition has yet to begin from passive knowledge-consuming adolescents to young professionals who reason with theory and are able to reflect. Therefore, we started a program where chemistry, learning and reflection are intertwined in one course with one teacher. The course is very process-driven and focusses on students' own past and present learning, and understanding and relates it to their future pupils. Conceptual change theory is the foundation for cognitive and affective learning, by reflecting on their own knowledge adaptation. I will present how this conceptual change process is conducted, the material (e.g., concept cards, learning diary) used and the requirements for the teacher.

Enhancing adults' intellectual humility in the context of science communication

Nina Vaupotič (vaupotic@uni-muenster.de), Dorothe Kienhues (kienhues@uni-muenster.de), & Regina Jucks (jucks@uni-muenster.de), University of Münster, Department of Psychology, Münster, Germany

Due to the high specialization of scientific knowledge and a low conceptual understanding, adults often rely on experts to gain information about science and to make decisions about socio-scientific issues. How science is communicated by experts therefore plays an important role in shaping people's beliefs about science, especially in informal learning contexts.
In an experimental study, adult participants (N = 273) read an online interview with a geophysicist who either took a stance for decommissioning nuclear energy plants or not. After reading, the participants wrote a text with the goal to either inform or to persuade an acquaintance about their own position. To capture successful engagement with scientific information, we measured participants' intellectual humility, perceived easiness of a simple solution, strategies to cope with a complex topic, and argumentation style.
If the geophysicist took a stance for decommissioning nuclear power, participants' intellectual humility was lower, whereas their perceived easiness of a solution and their willingness to act were significantly higher. Writing a text with the goal of persuading led to a significantly stronger perceived easiness of a solution and a significantly more one-sided argumentation.
These findings imply that when an expert takes a position, this can give clarity to non-experts and enhance their willingness to act, but it can also make them less humble about the amount of knowledge they possess about a specific topic. For educational purposes, communicating to inform rather than communicating to persuade may be beneficial for developing a more two-sided understanding of socio-scientific issues.

Symposium 4

Pluralist perspectives on conceptual change

Saturday 27 August 2022 9:00 – 11:00

Room: Auditorium Chair: Michel Bélanger

Symposium Abstract 32

Research on conceptual change learning and teaching can be described as focusing on the process(es) of moving from students' initial conceptions to more scientific ones. Numerous aspects of this process have been explored over the years. The present symposium intends to focus on one that has not received enough systematic attention in the past, i.e. the increasingly recognized fact that, although we speak of conceptual change, this learning process, even if successful, often does not necessarily result in students having only one (scientific) conception in their mind. On the contrary, researchers become more and more aware that students, for various reasons, generally end up with several partly or completely incompatible representations of a single phenomenon. One reason is the possible persistence of students' initial conceptions and their possibly important cognitive role at the end of the learning process. This coexistence has received more empirical and theoretical attention in the past decade. Another reason concerns the target of this process (i.e. scientific representations themselves). Recent studies of scientists' actual practices and theoretical outputs have shown that these are better characterized as consisting in a plurality of often partially or completely incompatible models or theories about a single phenomenon. By acknowledging beforehand that plurality is a normal feature of students' and scientists' cognition and practices, the symposium aims to create a space for a deeper exploration of factors and processes that shape how the phenomenon of representational plurality takes place in learning.

Normativity and conceptual change models: the case of representational pluralism

Michel Bélanger (michel_belanger@uqar.ca), Université du Québec à Rimouski, Canada

The objective of this paper is to make apparent the issue of normativity in conceptual change research raised by its pluralist tradition. Indeed, one major strand of this tradition focuses on the persistence of students' non-scientific conceptions and thus their coexistence alongside the scientific ones, which are acquired through the science learning process. According to researchers from the pluralist tradition, science education should not simply aim to bring

students to understand and master a scientific representation, but should also help them effectively deal with a plurality of possible representations of a same phenomenon. In part 1, I will argue that such pluralist research raises the normativity issue, because it finds itself questioning what can and should be the aim of science education. In part 2, I will review major arguments and causes of representational plurality, and from this I will extract two main sources of norms or aims, each declined in several sub-sources. In the conclusion, I will argue that science education researchers should be more aware of the normative issue that is fundamentally present in conceptual change research.

KReC: Plurality in Knowledge Revision

Panayiota Kendeou (Kend0040@umn.edu), University of Minnesota, United States

Representational plurality is an important yet neglected phenomenon in knowledge revision research. In this presentation, we review the Knowledge Revisions Components framework (KReC; Kendeou et al, 2014), which makes several theoretical assumptions that directly implicate plurality and may offer one useful perspective to understand this phenomenon. First and foremost, KReC acknowledges that individuals may possess multiple, potentially incompatible beliefs about various phenomenon. Such plurality may or may not exist prior to an educational intervention, but the outcome of an intervention rooted in the KReC framework is, by default, pluralistic. Misconceptions cannot simply be erased and replaced. Rather they continue to co-exist with newly acquired corrective information. Further, these pluralistic representations continue to have an inherent competition for activation at every retrieval instance that reactivates them. In this context, the hallmark of a successful educational intervention is when a sufficient quantity and quality of alternative explanations reinforce the correct, evidence-based understanding, which enables it to become dominant in the conceptual network it shares with the misconception. Thus, in acknowledging this pluralistic reality, the goal of an educational knowledge revision intervention informed by the KReC framework is to find methods to advantage evidence-based concepts in their competition with misconceptions. We present examples from our own recent research from the specific lens of pluralism, and in particular, its effects on learning.

Reference

Kendeou, P., Walsh, E. K., Smith, E. R., & O'Brien, E. J. (2014). Knowledge revision processes in refutation texts. Discourse Processes, 51, 374-397.

Pluralism in economics education

Jack Reardon (jackreardon864@gmail.com), University of Wisconsin- Eau Claire, USA

In contrast with physics, chemistry and biology (which have been the original playground of conceptual change research for decades), economics is notoriously characterized by the plurality of its traditions. Whereas conceptual change researchers acknowledge more and more representational plurality as a consequence of the persistence of intuitive conceptions alongside acquired scientific representations, economics education researchers have been increasingly aware of a representational plurality created by the multiplicity of scientific theoretical perspectives in the discipline itself. This paper discusses the role of pluralism in economics education. The paper is divided into five sections. Section one will briefly discuss the historical evolution of pluralism, tracing its origin to the late 19th century. Section two will define pluralism "a willingness to recognize, listen to, and dialogue with alternative views." Section three will discuss the learning difficulties associated with pluralism, pointing the finger at economics education. Section four will offer teaching strategies to implement pluralism, and section five concludes.

The meaning of 'change' in the post representational plurality era of the conceptual change paradigm

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The first part of this presentation will discuss the growing evidence coming from research in the area of science education but also in other areas of research, including teacher education, that learners' initial conceptions are not replaced by scientific representations but co-exist with them influencing reasoning and decision making. These findings do indeed challenge traditional theories of conceptual change according to which initial conceptions are supplanted by the scientific representations when these become available through instruction and necessitate at least a re-assessment of the notion of 'change' in the conceptual change paradigm. In the second part of my presentation I will argue that there is still room for 'conceptual change' in the post representational plurality era. This type of conceptual change is not one of 'substitution' but one where the learner moves from being able to consider only one representation for a given phenomenon in the world to being able to create and explicitly handle multiple representations correctly. My argument requires making a distinction between holding more than one representation unknowingly – without knowing or realising that the refer to the same situation in the world – versus knowingly – i.e., explicitly holding and flexibly navigating amongst multiple representations. Empirical findings will be presented to support this argument.

Symposium 5

Cognitive Conflict between Science and Intuition: New Empirical Investigations and a Cognitive Model

Saturday 27 August 2022 11:30 – 13:00

Room: Auditorium Chair: Peter Edelsbrunner

Symposium Abstract 33

In 2012, Shtulman and Valcarcel found that individuals need longer and make more errors in verifying statements about scientific phenomena when the intuitive and scientific theory about the phenomenon are inconsistent. This observation was interpreted as a robust demonstration of the interference between intuitive and scientific theories, implying that earlier intuitive theories persist after new scientific theories have been acquired. The present symposium presents three new studies on this experimental paradigm. In the first study, this statement-verification task is applied to decision-making about social categories in which generic beliefs are sometimes inconsistent with statistical beliefs. The authors find that on average, individuals verify statements consistent with generic beliefs more accurately than those inconsistent with generic beliefs but are not faster to do so. Conflict between generic and statistical beliefs also predicts two measures of stereotyping. The second study investigates conflict between scientific and intuitive theories in students before and after they receive instruction on the topics of magnetism and electrostatics. The authors find higher accuracies for consistent statements than for inconsistent ones, but no overall difference in reaction times. In the third study, a (statistical) cognitive model of the statement-verification task is presented and applied to the data from two studies. The model fits the data well, showing how inconsistency affects information accumulation during the decision process, and how effects differ between individuals. The contributions show the robustness and limitations in the generalizability of findings of cognitive conflict and their implications for conceptual change theory and research.

Conceptual Change Meets Social Change: Cognitive Conflict When Reasoning About Social Categories

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Andrew Young (A-Young20@neiu.edu), Northeastern Illinois University, United States

Our knowledge of social categories consists of two types of beliefs: generic beliefs, like "women are nurturing" or "conservatives are intolerant," which apply to the entire category, and statistical beliefs, like "many women are nurturing" or "some conservatives are intolerant," which qualifies the applicability of such traits. Here, we use the tools of conceptual change research to explore the conflict between generic and statistical beliefs and whether that conflict predicts the endorsement of social stereotypes. Participants (216 college undergraduates) verified statements about four social categories (gender, race, political orientation, and sexual orientation) that pitted generic beliefs against statistical beliefs, as in (1) "many women are nurturing," which is both generically true and statistically true; (2) "all men are nurturing," which is both generically false and statistically false; (3) "all women are nurturing," which is generically true but statistically false; and (4) "many men are nurturing," which is generically false but statistically true. As a group, participants verified statements in which generic beliefs and statistical beliefs converge (1 and 2) more accurately than statements in which they diverge (3 and 4) but were no faster to do so. As individuals, participants who responded more accurately to the latter type of statement, discounting generic beliefs in favor of statistical beliefs, treated contrasting social categories more equitably on two measures of social stereotyping. Our findings suggest that maladaptive social attitudes may arise from mutually incompatible representations of social categories and that social reasoning, like scientific reasoning, may entail some form of conceptual change.

Intervention Effects on Conceptual Co-existence in Magnetism and Electrostatics

Christian Thurn (christian.thurn@ifv.gess.ethz.ch), ETH Zurich, Switzerland

In their speeded-reasoning task, Shtulman and Valcarcel (2012) investigated how statements that are consistent with naïve and scientific concepts are solved in comparison to inconsistent statements that are wrong either from a naïve or scientific point of view. We extended this work by measuring performance of two groups with different prior knowledge before and after instruction, and relating the results to a multiple choice concept test. In the context of magnetism and electrostatics, 64 students (M = 14.0 years, 35% female) who had high prior knowledge on the topic of magnetism were compared to a control group of 38 students (M = 14.0 years, 49% female) with no prior knowledge on that topic. All students received 5 lessons

on the topic of magnetic and electric fields taught by the same teacher and accompanied by pre- and posttest. The results showed significantly higher accuracies for consistent statements (83%) than for inconsistent ones (50%). The group with prior knowledge solved the items more accurately than the control group, but not significantly faster. Both groups showed faster reaction times at the posttests. Accuracy correlated positively with the score of a multiple choice concept test, but only moderately, indicating that these measures grasp different aspects of content knowledge. The difference between consistent and inconsistent items indicates that cognitive conflict remains also after instruction and that students profit from prior knowledge when solving such items. However, the findings might indicate that prior knowledge does not make a difference in how fast one processes these statements.

The suppression of Intuitive Theories in Science: A Statistical Model of the Cognitive Process

Peter Edelsbrunner (peter.edelsbrunner@ifv.gess.ethz.ch), ETH Zurich, Switzerland
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Shtulman & Valcarcel (2012) showed that adults require longer and make more errors in the verification of scientific statements (e.g., "the sun revolves around the earth") when these are in conflict with their prior intuitive theories. This finding has been interpreted as indicating that intuitive theories are not replaced during the acquisition of scientific theories in schooling, but rather still exist and the interference has to be suppressed each time we face a related decision. This finding has been replicated across various contexts and populations; however, what is yet lacking is an adequate statistical model for the reaction times and decisions stemming from this experimental paradigm. Current studies employed analysis of variance, a generic statistical model that makes assumptions that are not met in a two-choice reaction time task and contain parameters with little established cognitive interpretation. In the present study, a Bayesian hierarchical diffusion model is fit to this type of experimental data from cognitive education science. Specifically, we apply a Wiener diffusion model to the data of Shtulman & Valcarcel (2012) and a similar study with a psychosocial stress manipulation. The model shows adequate fit. Parameter estimates reveal that the type of statement (consistency of scientific theory with naïve theory) impacts the drift rate parameter. The hierarchical nature of the model allows detailed analysis of how specific characteristics of the statements (e.g., scientific domain), persons (e.g., age, educational background), and the experiment (e.g., stress intervention) influence reaction times, decision probabilities, and the interference effect.

12th International Conference on Conceptual Change

"Learning with Conceptual Change in higher Education and Professional Practice"

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