



# LUMAT Research Symposium

*Promoting STEAM in education*

June 3-4, 2020

Conference Book

Organized by LUMAT Science Research Forum



**LUMA-KESKUS SUOMI**  
**LUMA-CENTER FINLAND**  
**LUMA CENTRE FINLAND**

## Welcome to the symposium

International LUMAT Research Symposium gathers teachers and researchers from around the world to learn, share ideas and collaborate. The theme of the symposium 2020 is *Promoting STEAM in education*. The STEAM in this case stands for Science, Technology, Engineering, All subjects, and Mathematics. We invite research-based discussions on how to make connections within STEM and with STEM and other fields, such as arts, social science, and sports, to name but a few.

This year the symposium is organized online, challenging us to communicate and share our research in a different manner. This is one example of a situation in which we need new kinds of thinking and new ways to approach teaching, learning, collaborating and conducting research.

The symposium consists of keynote talks, oral presentations, and poster sessions. The keynote talks address the possibilities of STEAM in this current situation introducing the silver lining of STEAM and sense experiences in STEAM-oriented inquiry.

Oral presentations capture STEAM in various angles. The themes of the oral presentations are:

- Emotions, drama and game-based learning in STEAM education
- Thinking and STEAM: algorithms and databases
- Nature of science and teachers' beliefs in STEAM education
- STEAM in educational programs

Poster presentations introduce us new research-based approaches to STEAM and practical and creative approaches to STEAM, giving ideas and examples on how to carry out STEAM in various institutional levels.

Symposium proceedings are published in the *LUMAT* special issue:

<https://journals.helsinki.fi/lumat/steam>

*Welcome to our virtual symposium organized by LUMAT Science Research Forum!*

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# Program

## Schedule

Time*		Program
<b>Wed 3.6 morning</b>	<b>10.30–11.30</b>	<b>Opening of the symposium</b>
	11.30–12.00	Break
	<b>12.00–13.00</b>	<b>Oral presentations 1</b>
	13.00–14.00	Break (Zoom is open for conversation at 13.00-13.30)
<b>Wed 3.6 afternoon</b>	<b>14.00–15.00</b>	<b>Oral presentations 2</b>
	15.00–16.00	Break (Zoom is open for conversation at 15.00-15.30)
	<b>16.00-16.45</b>	<b>Poster session 1</b>
	16.45–18.00	Break
	<b>18.00–19.00</b>	<b>Keynote 1</b>
<b>Thu 4.6 morning</b>	<b>10.00-11.00</b>	<b>Keynote 2</b>
	11.00–11.30	Break
	<b>11.30-12.30</b>	<b>Oral presentations 3</b>
	12.30–13.30	Break (Zoom is open for conversation at 12.30-13.00)
<b>Thu 4.6 afternoon</b>	<b>13.30-14.30</b>	<b>Oral presentations 4</b>
	14.30–15.30	Break (Zoom is open for conversation at 14.30-15.00)
	<b>15.30–16.15</b>	<b>Poster session 2</b>
	16.15–16.30	Break
	<b>16.30–17.15</b>	<b>Closing words of the symposium</b>

\*Schedule follows Finnish time (UTC+3)

## Keynote talks

<p><b>Keynote 1:</b> Marina Milner-Bolotin  <b>Title:</b> The STEAM silver lining of the pandemic: Implications for teacher education  <b>Time:</b> Wed 3.6 June at 18.00 pm</p>
<p><b>Keynote 2:</b> Erik Fooladi  <b>Title:</b> Putting sense experiences at the front in STEAM-oriented inquiry  <b>Time:</b> Thu 4.6 June at 10.00 am</p>

## Oral presentation sessions

<p><b>Session 1: Emotions, drama and game-based learning in STEAM education</b>  <i>STEAM education supports teachers and students both cognitively as well as emotionally. This session concentrates on how to use eg. drama and games in STEAM, and how to especially take emotional aspects into account.</i>  <b>Chair:</b> Dr. Jaana Herranen  <b>Time:</b> Wed 3.6 June at 12.00 noon</p>	
<b>Title of the presentation</b>	<b>Presenter</b>
Facilitating Emotionally Engaging Drama Activities in Science Teacher Education	Jaakko Turkka and Maija Aksela
Promotion of the use of gamification among higher education teachers	Tadeja Nemanič, Sanja Jedrinović, Anja Luštek, and Jože Rugelj
<p><b>Session 2: Thinking and STEAM: algorithms, databases and virtual classrooms</b>  <i>STEAM education has the potential to support students` thinking. This session concentrates on the role of algorithms in problem-solving, and databases and virtual classrooms in learning, taking different aspects of supporting knowledge and thinking into account.</i>  <b>Chair:</b> Dr. Johannes Perna  <b>Time:</b> Wed 3.6 June at 14.00 pm</p>	
<b>Title of the presentation</b>	<b>Presenter</b>
Algorithms thinking and problem solving	Kalle Saastamoinen
Databases in teaching and learning chemistry in primary school	Katarina Mlinarec and Vesna Ferik Savec

<p><b>Session 3: Nature of science and teachers` beliefs in STEAM education</b>  <i>Teachers` beliefs are important to understand when developing STEAM education. This session concentrates on teachers` beliefs, and especially their role in nature of science. In this session both theoretical considerations (philosophy of science) as well as empirical research on nature of science and teachers` beliefs in STEAM are presented.</i>  <b>Chair:</b> Dr. Veli-Matti Vesterinen  <b>Time:</b> Thu 4.6 June at 11.30 am</p>	
<b>Title of the presentation</b>	<b>Presenter</b>
Science Education and Philosophy of Science	Arto Mutanen
Assessment of Hungarian preservice teachers beliefs about nature of science and scientific reasoning	Gabor Z. Orosz and Erzsébet Korom
Exploring In-Service Teachers Beliefs about STEAM Pedagogy in Chinese Primary Schools	Pei Zhao
<p><b>Session 4: STEAM in educational programs</b>  <i>Institutions are developing educational programs in different educational levels to promote STEAM. This session concentrates on research-based development from early years education to higher education, especially in teacher training.</i>  <b>Chair:</b> Dr. Johannes Perna  <b>Time:</b> Thu 4.6 June at 13.30 pm</p>	
<b>Title of the presentation</b>	<b>Presenter</b>
Promoting STEAM learning in the early years: Pequeños Científicos	Valeria M. Cabello and M. Loreto Martinez
Promoting the use of collaborative learning with ICT among higher education	Ana Žabkar Šalić, Sanja Jedrinović, and Anja Luštek, Jože Rugelj

## Poster sessions

<b>Poster session 1: Practical and creative approaches to STEAM</b> <b>Chair: Dr. Johannes Perna</b> <b>Time: Wed 3.6 June at 16:00 pm</b>	
<b>Title of the poster</b>	<b>Presenter</b>
An introduction to online STEM classes during emergency landing	Ferhat Ayranci and Busra Ayranci
The PHERECLOS project	Niko Kyllönen
SCIENCE PANTOMIME	Sanja Bulat and Bojana Mitriceski Andelkovic
How to teach Geographic information systems	Antti Rissanen and Kalle Saastamoinen
Phenomenon-based STEAM Learning for Raising Environmental Awareness	Anssi Lindell and Kristóf Fenyvesi
How can we use video conferencing with an expert to differentiate learning processes?	Jonas Bäckelin
Playful Development of Mathematical Thinking Skills in Primary and Secondary School with the Logifaces STEAM education Toolkit	Kristof Fenyvesi, Matias Kaukolinna, Natalia Budinski, and Dániel Lakos
Creative tools and gamification to talk to students about the climate change	Emma Abbate



<b>Poster session 2: New research-based approaches to STEAM</b>	
<b>Chair: Dr. Johannes Perna</b>	
<b>Time: Thu 4.6 June at 15:30 pm</b>	
<b>Title of the poster</b>	<b>Presenter</b>
Integrated STEM Activities for Developing Design Thinking in Egypt	Ahmed Hammam, Martin Lindner, and Heba EL-Deghaidy
Summer Code Club Petrila	Cîndea Nicoleta and Gogea Alexandru
Using computers to support education and learning	Kalle Saastamoinen and Antti Rissanen
The Design of the Two-tier Test to Diagnose Student Conceptual Difficulties about Heat and Temperature	Abdeljalil Métioui and Louis Trudel
Chemistry Education In The Anthropocene	Merve Nur Yavuzkaya, Helen Hasslöf, and Jesper Sjöström
Can science make a difference when music education is the main goal?	Erik Fooladi and Siv Kristin Aurdal
Exploration of TDS students' choice of mathematical concept	Antje Meier
Pre-service Teachers Views on their Campus Garden Based Teaching Practice	Sibel Telli
Ecosystem Approach In The Content Of School Course Ecology	Ilia Danilin

## **Keynote talk abstracts**

### **The STEAM silver lining of the pandemic: Implications for teacher education**

Marina Milner-Bolotin

The University of British Columbia, Vancouver, Canada

#### **Abstract**

The first months of 2020 brought many unexpected challenges to teachers, parents, and students. The teachers had to learn on-the-go how to engage students in online learning environments. It became clear very quickly that to make online learning environments work, it is not enough to master the technological side of online learning. The teachers have to learn how to design authentic learning environments that will engage and challenge the students. This makes the integration of science, technology, engineering, arts, and mathematics (STEAM) even more relevant than ever before. At first glance the task might look difficult, as traditionally in K-12 schools these subjects have been taught separately and teachers rarely had a chance to collaborate on teaching integrated lessons or to engage students in long-term STEAM projects. However, today we have a great opportunity to ponder how we can break the traditional classroom walls and to consider novel learning opportunities that might not have been overlooked in the face-to-face classrooms. An opportunity to design novel online learning environments allows teachers to challenge how their students were learning before while drawing on students' passions, interests and strengths to facilitate more powerful engagement. For example, students can learn how to communicate science and mathematics ideas to the general audience using social media, such as YouTube. The students can investigate the science of music or to examine how artists, such as Leonardo da Vinci, integrated STEM to create their immortal works of art. In this presentation, I will discuss how we can educate future teachers who will be open and ready to collaborate with peers and create face-to-face and online STEAM learning environments. I will invite us to think about different ways of how we can use STEAM education to prepare future elementary and secondary teachers. I will discuss the role of modern technologies in STEAM classrooms and will bring two examples to illustrate these suggestions: Family Math and Science Day at the University of British Columbia and our online YouTube channel featuring educational STEAM videos designed by future teachers.

## Author bio

Marina Milner-Bolotin, Ph.D. (<http://blogs.ubc.ca/mmilner/>) is an Associate Professor in the field of Science Education in the UBC Department of Curriculum and Pedagogy at the University of British Columbia, Vancouver, Canada where she teaches undergraduate and graduate science education and educational technology courses. She also teaches in the fully online Master of Science Education Program at UBC. Her favourite online course is EDCP 544 that focuses on mathematics and science teaching in technology-enhanced learning environments. Her areas of research include science (physics) and mathematics education, educational technology in mathematics and science, and teacher education. She has been teaching mathematics and science in K-12 schools and at the undergraduate level for more than 25 years in the Ukraine, Israel, the United States, and Canada. She is actively involved in provincial, national and international organizations focused on improving science and mathematics education, such as the American Educational Research Association, American Association of Physics Teachers, Canadian Association of Physicists, Canadian Society for the Study of Education, and the British Columbia Physics Teachers' Association.

Dr. Milner-Bolotin's research publications include more than 50 peer-reviewed papers, eleven book chapters, an edited book, a collection of mathematics problems for gifted students, and an undergraduate physics textbook used throughout Canada and internationally. She has received a number of local, national, and international research grants to study the implementation of technology in mathematics and science education, including the NSTA Vernier Award (2006), and HP Educational Innovation Grant (2008). In 2010, she received a Canadian Association of Physicists Teaching Medal for Excellence in Undergraduate Physics Teaching. In 2014, she received a UBC Faculty of Education Killam Teaching Prize. During 2008-2018, she served as an Association Editor of the journal *Physics in Canada*. In 2016, she was invited to become a member of the Editorial Board of the LUMAT, Finnish Mathematics and Science Education Journal. In 2017, she became an Associate Editor of Frontiers, Science Education Journal. She is currently studying how active engagement of physics teacher-candidates with technologies during their physics methods courses promotes the development of their capacity for Deliberate Pedagogical Thinking with Technology and their willingness to implement active engagement pedagogies in their courses.

# Putting sense experiences at the front in STEAM-oriented inquiry

Erik Fooladi

Volda University College, Norway

## Abstract

In the present keynote lecture I take departure from science education and seek to investigate conditions of various forms of disciplinarity (Ramadier, 2004) within the context of STEAM. For this purpose, a threefold foundation from educational research and theory is used. Firstly, the commonplace notion that education should seek to promote learning not only of declarative knowledge (“learning facts”), but also practices and ways of thinking (e.g. Crawford, 2014; Rönnebeck, Bernholt, & Ropohl, 2016). Secondly, the fact that STEAM as movement and phenomenon has increased the motivation to seek for interdisciplinary approaches in education (Colucci-Gray et al., 2017; Costantino, 2018). However, with interdisciplinarity follows not only possibilities for productive collaboration, but also encounters of different cultures and manners of being and communicating (Gee, 2015). With this, again, follows issues of power relations and frictions. Thus, not only possibilities, but also conditions for various forms of disciplinarity should be investigated when dealing with STEAM. Thirdly, I build on the normative stance of Dahlin and others that that science education has for a long time given too high priority to abstract and idealised descriptions over immediate, sensuous experiences of the world, and that we therefore should seek an education where immediate sense-experiences play a more prominent role (Dahlin, 2003; Østergaard, 2015). With these perspectives as backdrop, and some selected classroom examples (Fooladi, 2020; Herranen, Kousa, Fooladi, & Aksela, 2019), I seek to discuss various notions of disciplinarity, the nature of inquiry across subjects, and thereby uncover both possibilities and challenges in inquiry-oriented STEAM education. In short: How can inquiry be conceptualised when different subjects, with their distinct practices and ways of thinking, meet in the context of STEAM?

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## Author bio

Erik Fooladi holds a doctorate in organometallic chemistry from University of Oslo, and is presently associate professor in science education and home economics at Volda University College, Norway. He has an extensive production of teaching resources and popular scientific material in the interface between science and food, amongst other as co-author of the popular science book “A Pinch of Culinary Science: Boiling an Egg Inside Out and Other Kitchen Tales” (published in Finnish as “Hyppysellinen tiedettä”). His research interests are education and communication in the intersection between food, science and sense/ory experiences, particularly on inquiry, argumentation, context-based education and epistemic perspectives in transdisciplinary contexts. He is also a musician (percussionist), and collaborates with both researchers, artists and other practitioners to produce multisensory performances and research.

## **Abstracts of the oral presentation sessions**

### **Session 1: Emotions, drama and game-based learning in STEAM education**

**Time: Wed 3.6 June at 12.00 noon**

#### *Facilitating Emotionally Engaging Drama Activities in Science Teacher Education*

Jaakko Turkka and Maija Aksela

Unit of Chemistry Teacher Education, University of Helsinki, Finland

### **Aim**

The aim of this study is to support facilitation of emotionally engaging drama activities in science teacher education. Drama activities have been found to promote science students learning, motivation, social skills and agency (Lee et al., 2015). Yet, drama is rarely integrated in science education (Turkka et al., 2017). Moreover, drama activities have been associated with the possibility to elicit anxiety in some students (Heyward, 2010). One reason for rare integration and association with anxiety is that the possibilities and challenges of emotionally engaging drama facilitation are not sufficiently understood in science education research.

### **Research setting**

This case study explores the possibilities and challenges of drama facilitation in science teacher education. The data consists of a video recording of a session, in which pre-service science teachers (PSSTs) were introduced to drama activities, and group interviews conducted after PSST groups had facilitated drama activities for younger students visiting during their visit at the university. Following the example of Mayring (2014) we used inductive content analysis to form a category system to outline the PSSTs perceptions of the opportunities and challenges of facilitating drama activities. Our initial categories were based on previous work on initially emotional engagement in drama outside the context of science education (Bolton & Heathcote, 1999; Heyward, 2010).

### **Results**

Using the abductive logic of case studies we discuss our category system with previous research to find the best available explanations for our observations (Thomas, 2010). The result is a pragmatic

theory about opportunities and challenges of drama facilitation. The opportunities include emotionally engaging moments that lead to creative expressions, and diverse conceptual learning opportunities. The challenges include finding the right level of difficulty, verification of learning, and establishing safety. The results help science teachers and their educators to structure emotionally safe drama activities and recognize the learning opportunities of emotionally engaging moments, which often occur unplanned.

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### *Encouraging the use of gamification among higher education teachers*

Tadeja Nemanič, Sanja Jedrinović, Anja Luštek, and Jože Rugelj  
Faculty of Education of the University of Ljubljana, Slovenia

Keywords: game-based learning, gamification, SAMR model, revised Bloom digital taxonomy, didactic use of ICT

Two main perspectives on the use of games in higher education developed — game-based learning, in which actual games are used in the classroom to enhance learning and teaching, and gamification, which advocates the use of game-design elements in non-game contexts. To inform higher education teachers about game-based learning and gamification of learning supported with ICT, the online course was prepared at University in Ljubljana within the project “Digital UL — With Innovative Use of ICT to Excellence”. This paper presents findings from the evaluation of an online course



entitled Gamification supported with ICT, which has been administered to 18 higher education teachers in the field STEAM of the University of Ljubljana. The data was collected with a questionnaire, followed by the analysis of the reports with redefined study activities that the higher education teachers developed at the end of the course. Each activity from teacher reports was first categorized based on the revised Bloom's digital taxonomy (Anderson et al., 2001) and then based on the SAMR (Substitution, Augmentation, Modification, Redefinition) levels (Puentedura, 2014) of ICT integration in the teaching process. The results suggest that STEAM higher education teachers recognized the added value of the content of the course since they found it relevant for their field of teaching and developed activities that are encouraging the development of different levels of thinking skills among students. It was also found that with the online course the teachers were encouraged to redefine their study activities on different SAMR levels. While designing study activities STEAM teachers used different tools that support gamification. Based on the evaluation of teachers' reports we will prepare examples of the use for emphasized ICT at different SAMR levels and step-by-step instructions for different ICT for game design.

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## Session 2: Thinking and STEAM: algorithms, databases and virtual classrooms

**Time: Wed 3.6 June at 14.00 pm**

### *Algorithmic thinking and problem solving*

Kalle Saastamoinen

National Defence University, Finland

Keywords: algorithms, education, problems, solving, thinking

In this article, we discuss the importance of algorithmic thinking in general. Algorithmic thinking is essential in programming. Algorithms put bigger problems into the smaller pieces, and give original problem simpler mechanical step-by-step recipe for the solution. Algorithms can be represented linguistically, flowchart or as pseudocode. Most problems can be presented in algorithmic form; it brings logical structure to the problem solution and helps to find most effective solution. If one can write problem solution into the algorithmic form it can transformed into the computer program.

Nowadays algorithms affect a lot for everybody's life, through social media, taxes, work applications, automated profiling, politics, economics etc. No matter how important they are, they are quite little actively educated. In elementary schools subtraction, division and multiplication are examples of algorithmic thinking and algorithms would be an obvious way to improve students' conceptual understanding, rather than knowing mainly isolated facts and methods.

Many people think first problem solving when they hear the word algorithm (Kaleliolu, 2016) and they have a clear connection into the problem solving (Denning, 2017) and Blooms taxonomy (Selby, 2014). Algorithmic thinking concentrates into the thinking process and applications (Wing, 2006). Algorithmic thinking (AT) means a method, which solves the problem after well-defined steps (Csizmadia, 2015). Algorithmic thinking has three main themes, which are 1) data collecting, analysis and presentation 2) breaking problem into the pieces, algorithms, abstraction and parallelism 3) automata and simulation (Mannila, 2014). According Polya there are four phases of the problem solution 1) understanding the problem, 2) devising a plan, 3) carrying out the plan, and 4) looking back (Pólya, 1971). Hardest thing is to understand, which is not trivial skill and where one normally needs creativity.

This article starts by presentation of importance of algorithms, second part is devoted to the algorithms in education, third part considers algorithmic thinking and fourth part is about algorithmic problem solving.

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### *Databases in teaching and learning chemistry in primary school*

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Keywords: information and communications technology (ICT), in-service-teacher training, chemical databases, massive open online course (MOOC), teaching chemistry, chemistry teachers

Databases have an important part in teaching and learning chemistry because of the need to empower students with knowledge needed to search and retrieve information, to develop critical thinking, which is crucial in the age of increasing amount of information in the field of science (Baysinger, 2016; Redecker, 2017; Tuvi-Arad and Blonder, 2019). Many chemical databases with an open access are invaluable for both researchers and chemical educators at all levels in terms of ease of use, the extent of information and overcoming time and place barriers (Tuvi-Arad and Blonder,

2019). Researchers also highlight the lack of research papers and publications on the use of chemical databases in class evaluating the learning processes of both chemistry teachers and students (Tuvi-Arad and Blonder, 2019).

The purpose of this paper was to find out in which curriculum content teachers are most likely to use chemical databases, what are the challenges and opportunities, the factors that influence the quality of a database use in teaching and learning chemistry, what course topics according to the teachers are most important and would help them to use databases more often and more successfully. Based on a qualitative research we carried out semi-structured interviews with ten chemistry teachers in primary school. After analysing results we developed a massive open online course (MOOC) on the use of databases in teaching and learning chemistry which lasted two weeks.

After the course we once again carried out semi-structured interviews with seven chemistry teachers who completed the course to find out the extent to which the course has helped to broaden and upgrade their knowledge of databases, to think about the potential of their use in teaching and learning chemistry, and to surpass the identified problems in interviews prior to the online course.

The results of our research showed that online course encouraged teachers to think about the use of databases in relation to different contents of the chemical curriculum in primary school. Although there are some challenges teachers have when using databases in chemistry class, they can also find solutions how to tackle them. Teachers have also recognized the important value of using chemistry databases in chemistry class in the beginning of the course and even more so in the end. Teachers' knowledge was the most important factor regarding quality use of databases in chemistry class.

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## Session 3: Nature of science and teachers' beliefs in STEAM education

**Time: Thu 4.6 June at 11.30 am**

### *Science Education and Philosophy of Science*

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Science education aims to increase the understanding of science. Science is a multidimensional cultural product in which scientific knowledge production plays central role. To understand logic of scientific knowledge production we have to specify notions like scientific research process, scientific method, and scientific knowledge. That is, we must explicate what is scientific knowledge, how it is achieved and justified. So, to achieve the goals of science education, the history and philosophy of science could be used. However, learning and understanding are open-ended processes which entail that science education must be planned as endless and ever-renewing processes (Matthews 2014). Knowledge production can be characterized as model-based approach which is closely connected with structuralist approach in the philosophy of science (Tala 2015). The fundamental idea within structuralist approach was to connect philosophy of science and actual scientific inquiry more closely together. However, model-based approach can be enlarged the characterization of learning of science to more general relationship between science and society which has been a main idea in context-based or Science-Technology-Society (STS) approach (Bennett, Lubben & Hogarth 2007). STS approach is closely connected to technical sciences which unify theory and practise.

So, we have to analyse general human deliberation instead of mere scientific method which entails changes in methodological approach. General human deliberation is closely connected to the method of analysis and synthesis which originates to works of Aristotle. Moreover, the method of analysis and synthesis allow us to analyse more closely scientific research process or scientific discovery. (Niiniluoto 2018; Hintikka 2007.)

This shows explicitly how philosophical and historical analysis is needed in orientating science education. Moreover, the philosophical analysis must be context sensitive such that the needed conceptual nuances can be specified (Hintikka 2007). To achieve the pedagogical aims of the approach we have to generate a pedagogy-oriented dialog which presents the methodological approach as a systematic pedagogical doctrine (Mutanen 2016).

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### *Assessment of Hungarian preservice teachers' beliefs about nature of science and scientific reasoning*

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Among the main objectives of science education, there is a great emphasis on understanding the nature of science (NOS) and improving scientific reasoning. To achieve these goals, teachers themselves must have accurate beliefs and developed reasoning skills. However, preservice teachers' beliefs may not be sophisticated enough (Cofré et al, 2019), and their scientific reasoning could be further improved (Koenig et al, 2012).

In our study we assessed Hungarian first-year preservice teachers' beliefs about NOS and scientific reasoning skills. Our research questions were:

- How sophisticated beliefs do they have about the NOS?
- How developed are their scientific reasoning?
- Are there any differences in those by major as a background variable?

Participants were 84 Hungarian first-year preservice teachers (Mage=20.16, SD=1.45, 28.6% male). Among them 72.6% have a major connected to humanities, social-sciences and arts, while 27.4% have a major connected to science. Beliefs about NOS were assessed with the adapted, paper-and-pencil version of Liu and Tsai's (2008) questionnaire Scientific Epistemological Views (SEV). The instrument contains 20 items (GLB=0.91) with five-point scales (1: completely disagree, 5:

completely agree) covering the following aspects of NOS: standards of scientific research (SSR), social dialogue (SoD), sources of ideas (SI), the role of creativity (RC), cultural impacts and changing and tentative feature of science knowledge (CT). The higher scores indicate more sophisticated beliefs. Background questions were added to explore respondents' age, gender, faculty and major. Scientific reasoning was assessed with the digitalized version of Lawson's (2000) Classroom Test of Scientific Reasoning (LCTSR) (GLB=0.93), comprising 24 force-choice items. The data were collected in February 2020. Participation was voluntary.

Regarding the beliefs about NOS, the highest mean was recorded on SoD ( $M=3.89$ ,  $SD=0.67$ ) and the lowest on SI ( $M=3.28$ ,  $SD=0.78$ ). Students with science major gave significantly higher scores on SSR ( $t(39,8)=2.48$ ,  $p<.05$ ) and RC ( $t(61,0)=2.78$ ,  $p<.05$ ). The average performance on the LCTSR was moderate ( $M=44.3\%$ ,  $SD=17.5\%$ ) without any significant difference by faculty. Since the scores on SEV questionnaire and LCTSR were lower than we expected, we believe our students could benefit from additional support in each aspect of NOS and scientific reasoning. In order to improve our teacher training, it would be useful to assess preservice teachers' content knowledge as well.

## Acknowledgments

The study was supported by the ÚNKP-19-3 New National Excellence Program of the Hungarian Ministry for Innovation and Technology.

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*Exploring In-Service Teachers Beliefs about STEAM Pedagogy in Chinese  
Primary Schools*

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Teachers' beliefs contribute significantly to their teaching actions and performances. This research utilises a quantitative research method to explore K-12 teachers' beliefs about STEAM education by using the case of one city in northern China. An online survey on teachers' beliefs about STEAM education consists of four parts' awareness, STEAM teaching competency, values and attitudes towards science, technology and art.

Data were collected from 85 K-12 teachers in a city in northern China. The result explores K-12 teachers' beliefs about STEAM education, and shows that teachers' gender, STEAM experiences and areas of teaching are mainly related to their beliefs about STEAM education. Finally, this paper makes some recommendations to help make teachers' beliefs about STEAM education more positive.



## Session 4: STEAM in educational programs

**Time: Thu 4.6 June at 13.30 pm**

### *Promoting STEAM learning in the early years: Program "Pequeños Científicos"*

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Keywords: STEAM, learning, early years

## Introduction

In the last decades, the interest of educators and scientist in early science learning has increased (Sharapan, 2012; DeJarnette, 2018). Indeed, education in the early years is an excellent space for promoting integrated learning and going beyond the specificities of disconnected disciplines (Akturk & Demircan, 2017). The STEAM education (Science, Technology, Engineering, Arts and Mathematics) has gained force globally, mostly in developed countries (Akturk & Demircan, 2017).

However, in developing areas such as Latin America, STEAM education is incipient and focused mainly on secondary education perhaps their effort on guiding scientific vocations or reducing gender inequalities (García-Holgado et al., 2019). Our study centres on a pioneer educational program in Chile, oriented to extracurricular educational enrichment to students from 3 to 10 years old called "Pequeños científicos" which has been conducted by the centre for studies and the development of talents, PENTA UC.

The program seeks to increase young children's positive attitudes towards learning the disciplines and promote XXI century skills such as creativity, problem-solving and systemic thinking. The program has been offered during a school holiday week, twice per year (summer and winter), inside a university. In ten years of implementation, the program has reached several students with courses designed and taught by scholars, researchers and educators. The current innovation of the program embeds arts, technology and mathematics within science courses, taking the explicit mission of promoting STEAM education with a female-gender affirmation approach. The courses have an integrated STEAM focus instead of a unique emphasis on the disciplinary aspects, enhancing the critical role of women in the developments of each discipline. From this

approach, there are also elements of nature of science afforded by the courses, though hands-on, inquiry and modelling based learning.

## **Research methods**

We conducted an integral assessment of the program based on practitioner-research. The study explored the perceptions of the main actors of the program combining students, researchers and educators' views. An attitude survey was adapted and applied to the students. Additionally, group discussions about the implementation with the teachers and researchers were led and systematized.

## **Results**

The results show a) the favourable characteristics -such as allowing young learners to visualize scientific work as an integral and creative endeavour-, b) strengths -the integration of disciplines and the interests of young learners to join a university program based on research- and c) difficulties -i.e. the limitation of valid measurements or quantifiable students' advances in a short period-. These elements are essential to improve the design and implementation of educational innovation to promote STEAM learning beyond the regular classroom.

## **Conclusions**

We discuss the potential of transferring the alliance between the university context and early childhood education to diverse educational contexts of this model. We also problematize and demystify stereotypes about the capabilities of young children in STEAM learning, standing from the notion that enriched opportunities for learning are not only valuable for children's education but trigger their development in several dimensions. The limitations of the implementation and the study open new questions and suggestions for researchers and educators.

## **Acknowledgments**

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### *Promoting the use of collaborative learning with ICT among higher education teachers*

Ana Žabkar Šalić, Sanja Jedrinović, Anja Luštek, Jože Rugelj University of Ljubljana

Keywords: collaborative learning, higher education, SAMR model, revised Bloom's digital taxonomy, ICT

## Introduction

Collaborative learning is one of the most important approaches to teaching and learning at all levels of education, as it promotes higher cognitive processes and teaches students social skills. It is therefore a very important approach to learning in higher education. In the 21st century, the increasing development of ICT has expanded the possibilities of computer-based collaborative learning in the educational process. The question remains how digital technologies can support collaborative learning.

## Research methods

That is why we have developed an online course at the University of Ljubljana to promote ICT-supported Collaborative Learning as part of the project "Digital UL - With Innovative Use of ICT to

Excellence", which was conducted among 10 university teachers in the area of STEAM. During the course, teachers were introduced to a variety of tools that support collaborative learning. In the final task of the workshop, the teachers themselves tested the tools for educational purposes. The article analyzed the final survey and the final reports of the online course to determine what tools were chosen by university teachers in the area of STEAM promoting collaborative learning, what cognitive processes were promoted by Bloom's revised digital taxonomy (Anderson et al., 2001) and how teachers intended to use the selected ICT according to the levels of the SAMR model (Puentedura, 2014).

## Results

In the analysis we found that teachers chose different types of tools and used them at different levels according to the SAMR model, selecting different activities to promote different social skills and higher cognitive processes according to the revised Bloom's digital taxonomy. The results of the final survey underline the usefulness of the online course, which brought new knowledge to university teachers, the teachers got to know the different new ICT and highlighted the good comparison of the functionality of the ICT presented. On the basis of the feedback from the teachers, we want to focus on collaborative problem-based and project-based learning in the future. We will also adapt assessment activities to support the development of higher cognitive processes among teachers during the online course.

## Acknowledgments

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## Abstracts of the poster sessions

### Poster session 1: Practical and creative approaches to STEAM

**Time: Wed 3.6 June at 16:00 pm**

#### *An introduction to online STEM classes during emergency landing*

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Keywords: STEM, online learning, Covid-19

## Introduction

Everyone here has the sense that right now is one of those moments when we are influencing the future. -Steve Jobs

These difficult times bring some enforced opportunities to understand the nature of distance learning. Especially for STEM education and STEM learning where hands-on practices are a must to use, educators should figure out a more daily-life friendly approach. The implementation of a new approach should cover most of the formal education institutes. This implementation of a new approach does not mean to discover new educational theories but to carry out in-class STEM lessons to a distance or adjusting and using 21st century skills and collaborative skills such as collection of experimental data, student feedback, and assessment using forms, spreadsheets with data pooling and discussion through chat box for paperless and distance learning. (Sinex et al, 2016)

In this mini research, the ways to extend formal and classroom based STEM learning practices to distance learning tools, and designing solutions in order to increase the efficiency of online STEM classes and short-term effects of these on students are discussed. Two leading teachers in two STEM subjects (Science, Mathematics) with 7 different grade levels participated in this highly authentic classroom research. While the time of this classroom research is the age of Covid-19 which can also be called emergency landing of educational institutions, the main aim of this research is to lead future researchers to focus on distance learning as a whole educational approach not just a

supportive mercenary. It is obvious that, the quality of students' learning depend on improved new methods of teaching instead of traditional classroom practices both in classrooms and in distance learning. (Markova et al, 2016). Research questions were:

- What are the first responses of teachers and students to the distance learning during the Covid-19 time?
- What are the effects of the distance learning time on students' behaviours?
- What can make distance learning more efficient?

## Research methods

It is very important for a teacher to understand the efficiency of her/his own practice. (Anderson et al, 1994). This qualitative mini research focuses on analysing the changes in students' behaviours and teachers' responses to the requirements of Covid-19 school closures. The online classroom practices and responses of students and also responses of teachers to this new environment are compared to the past calm classroom times in order to understand the change.

## Results

1. Data Gathering: This research was conducted for two months from March 18, 2020 to May 15, 2020. The number of participants who took part in this research is around 140 students in 7 different grade levels. There are 2 teachers who conducted the research as practitioners.
2. Instrument: There is a variety of ways to collect data used throughout the research. Teachers combined their daily experiences from the beginning to the end of the research. Formative assessment results, students' participation and assignment submission reports, emails to and from students/parents, one to one communication through different media (WhatsApp, Line etc.) were used to produce analysis mainly about all parts' responses and the differences in behaviours after the Covid-19 school closures.
3. Findings: Teachers' readiness in terms of technological tools and knowledge of technic issues provides advantage for practitioners. Emergency implementation of distance learning brings a shock (and stress) to both parties. This shock leads to great behavioural shifts in students.

## Conclusions

Both teachers and students are affected very much from the change of classroom medium. The feeling of being overwhelmed due to high level of cognitive load changed student behaviours dramatically.

The best lesson to gain from this experience is to get ready for massive distance learning practices and improve innovative methods that teachers use. Moreover, if not all, more teachers must be included in producing adaptive lessons for distance learning and must be directed to get familiar with online tools.

## Acknowledgments

We would like to thank our colleagues in Pan Asia International School, who shared their insights from their online classes with us.

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### *The PHERECLOS project*

Niko Kyllönen

SnellmanEDU / Children University, Finland

## Introduction

Aim PHERECLOS develops regional models of collaboration in education which follow an approach of Open Schooling. Based on the experience of Children's Universities as incubators of change in the



educational ecosystems, all relevant actors in an area will be involved in local clusters of education; may they be universities, governmental and non-governmental organisations, companies or other knowledge providers. In order to foster mutual learning and understanding, all relevant stakeholders of schools and their key players (children, teacher, parents, school heads) at the overlapping edges of formal and non-formal education will be heard. This process will continuously be informed by findings from academic implementation research.

## Settings

PHERECLOS develops models of collaboration in education which follow an approach of Open Schooling in six local education clusters (LECs), which include many of the mentioned stakeholders. These collaborative learning environments serve as experimental testbeds for schools and affect the quality of sciences engagement opportunities in general. The regional effectiveness and impact will lead to the development of implementation guidelines and policy briefs to enhance the sustainability of the overall approach, which is continuously informed by findings from academic implementation research. At the same time, the project aims to improve the quality of science engagement. PHERECLOS will implement a digital OpenBadge system which labels institutions as reliable and responsive actors allowing all LEC parties to become real agents of change in education. Besides, this ecosystem will highlight individual achievements with respect to STEAM engagement. Implementation in Finland SnellmanEDU's Children's University, as the only Finnish LEC, aims to transfer University level, formal science education to the province of Northern Savo via schools and teachers. Furthermore, we will communicate about science education straight to the homes via the web, as online-webinars. We already have plenty of experience for online webinars focused on adults, which supports us improving science communication both at the regional and the national level. As a result of the project we have designed and implemented a new science education instructor training for teachers, created new educational contents with the University of Eastern Finland and Tiedetuubi, distributed and tested new contents and ideas for children via K12 schools from Northern Savo, and arranged online-webinars on homes and schools.

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## *Science Pantomime*

Sanja Bulat and Bojana Mitriceski Andelkovic  
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Through various student interview, teachers noticed their need for a change in methods in acquiring and defining knowledge from natural sciences curriculum. Through experience with other activities that form a bond between natural sciences and art, it was concluded that merging science and art is something that motivates students in engagement during the process of gaining knowledge, in the process of research, in analysing and presenting personal knowledge to others. In this work, we showed how we implemented the Science pantomime projects.

## *How to teach Geographic information systems*

Antti Rissanen and Kalle Saastamoinen  
Department of Military tech, National Defence University, Finland

Modern navigational skills are needed in practise as well in many disciplines like geography. Geographic information systems (GIS) technology and it utilization methods relay on sophisticated data based approach. They are used through software in desktop computers or mobile applications. This study how to teach and implementing modern technology for geography and for officers' profession. We present observations on GIS education for BA level students as well how small group education in Master level works. To reveal obstacles on training with real GIS applications we present case base material how map reading and navigation differs when traditional methods or professional software have been utilized. In the discussion part of the study we ponder which type of classification or taxonomy would help to define learning objectives and learning activities for GIS related learning.

Keywords: GIS, navigation, group learning

## Introduction

In Finnish school orienteering is one of the popular outdoor sports that require navigational skills. Traditionally the track is passed with a map and compass to navigate from starting point through the track to the goal. Other subject where map-reading skills are needed is geography. Military tactics and operations rely on trace apple planning over maps. Likewise infrastructure in civil society relays on documentation how things are located. Geographic information systems (GIS) technology and related methods have transformed traditional maps and location related information towards data based information which is controlled through desktop computers and mobile applications.

Specialists consider that GIS itself is a promising artefact to implement modern technology. (Longley et al 2005) We see quite many everyday applications which are easy to use. Also classical methods of navigations are seen unnecessary to learn. More over the first impression of the principles of GIS are straightforward and the utilization of existing data sounds simple, in the deeper utilization or practice, it is not so.

Observations on GIS education in Master level with small group. To reveal obstacles on training with real GIS applications we have compared the collected data to our observations on BA-level introductory GIS teaching. The major aim was to see how deeper knowledge demands and more student centric learning methods would affect. Our research question were:

- How small groups can share their theme learning tasks to others.
- Students' evaluation of teaching with group orientation.
- Course evaluation

## Research methods

Action research methodology describes an experiential learning approach, with goals including refining the needs of the methods, knowledge and interpretations based on the understanding of previous cycles (O'Leary, 2004). Examination data and student evaluation of teaching (SET) were used aside of instructors own evaluation.

## Results

Compared to teacher centric courses students appreciated their own activity. Too much textbook based theory was not a good idea, it doesn't mater who will deliver it. On the other hand course implementations where GIS professionals visited the course, the accumulated peer learned theory

was in hand. Student evaluation of teaching (SET) gives invaluable information in teaching experiments. Even a standard SET must be calibrated and for the group dynamics also other information is needed. (Spooren et al 2013) Examinations and other data made clear that a profession specific classification or taxonomy would help to define learning objectives and learning activities for GIS related learning. Students' relative high motivation helped to accept wide course demands.

## Conclusions

Student centric, group based learning helps to go through theory. In practical issues working with groups may help to overcome limited teacher resources. Collecting data with SET helps to find out why some learning aims are overestimated and a new more realistic curriculum may be needed.

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### *Phenomenon-based STEAM Learning for Raising Environmental Awareness*

Anssi Lindell and Kristof Fenyesi  
University of Jyväskylä, Finland

The modern, multi-dimensional concept of environmental education places great emphasis on expanding and developing the sophisticated understanding of the factors involved in protecting and preserving natural environment. According to suggestions by UNESCO already in 1977, the main goal of environmental education is to develop necessary skills, engender responsibility and strengthen personal commitment so as to encourage individual participation in community problem-solving efforts. Educational methods geared toward the paradigm of cooperative learning, exploration, research-based approaches, critical thinking and responsible decision-making increasingly focus upon the complex development of environmental education capable of fostering an environmentally conscious citizenry. STEAM educational framework provides several opportunities to raise environmental awareness through inquiry- and phenomenon-based learning.

In this presentation we introduce various examples in teacher training, professional development and informal learning activities, which implement STEAM approach in environmental learning. In the first example, a mixed group of class, special education, chemistry and biology teacher students collaborated with Jyväskylä University Museum in a STEAM education project to address the 21st-century skills along with the shared vision of the sustainable development goals (SDG) by the United Nations. In the first part of the project the students introduced the SDGs and produced an exhibition about the four topics they considered the most important: (1) Affordable and clean energy, (2) Good health and well-being, (3) Wastefood and (4) Plastic waste. The two last topics were handled under the goal of Responsible consumption and production. In the second part of the project, the student designed, tested and assessed four parallel inquiry based learning units taking an advantage of the exhibition. The assignment required STEAM integration, active learning, differentiation and the use of diverse learning environment and community of learners. To find out students` citizens` ideas about the relation of the sustainable development and technological development, we designed a questionnaire with 8 claims to be assessed by a 5-step Likert scale from strongly disagree to strongly agree. The questionnaire was piloted by a group of students working on the exhibition and the learning materials. After revisions the questionnaire will be addressed to the exhibition audience. The analyses of the data from the pilot, will be discussed in the poster. The second and third example introduce STEAM-projects, which implement geometrical modelling in environmental problem-solving. Architectural concepts, like Warka water tower for learning about the water cycle and geodesic dome-building activities for initiating storytelling, role-playing activities related to develop sustainable thinking skills will be introduced in the presentation.

*How can we use video conferencing with an expert to differentiate learning processes?*

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Keywords: Technology-mediated knowledge processes, video conferencing, critical framing

## **Introduction**

A virtual interview with an expert situates the subject in the real world. It is important to create a clear learning objective and chunk instruction so students can complete one task at the time. In my development project, I have so far seen several benefits from using the initiative *Skype in the Classroom* from Microsoft Education.

## Aim

This is a development project in progress with focus on distributed learning in knowledge development. The aim is to introduce the concept of Critical Framing in order to support learners in questioning common sense assumptions found within discourses. The learners will critically view their study topic in relation to its context with the help from an expert. The learning process involves evaluating their own and other people's perspectives, interests and motives. The purpose of the project is to help implementation of video conferencing with an expert as a design element in the lesson plan for educators.

## Research setting

I was one of the first teacher in Sweden to make use of Microsoft's education initiative "Skype in the Classroom" (Microsoft, 2020), but already in 2011 there were 13500 participants worldwide. The Global Learning Connection event 2019 the community travelled 29 million miles in 48 hours and had participants from more than 110 countries. Today I'm participating in the Skype Master Teacher Program and are registered as a guest speaker on the topic of how Baltic Sea fish populations are affected by fishing, eutrophication and oxygen depletion (Microsoft, 2020a). This got me interested in the area of technology-mediated knowledge processes (TKP) and the conclusions was presented during the conference Next Generation Learning in 2019 (Dalarna University, 2019). The interpretation of the concept *Critical Framing* that I'm using is one of four design considerations in a pedagogy of multiliteracies described by Bill Cope and Mary Kalantzis (2009).

My focus is on the changes that new technology can be used for to differentiate the learning processes in classroom education. Digital communication has been highlighted in of the training module for educators in digital competence by the Swedish National Agency for Education. One of the assignments in the first section is to *"Plan to conduct a lesson where students use a digital tool to communicate with someone outside the classroom who has expert knowledge of the subject area you are working with"* (Skolverket, 2020).

## Main results

In order to promote STEAM in education my results suggest that the initiative *Skype in the Classroom* from Microsoft Education is a good way to support K-12 teachers to connect with experts from museums, historical sites, national parks and researchers in the field. The concept of critical framing provides options for self-regulation and encourages differentiated assessment by design.

Bill Cope and Mary Kalantzis use *Critical Pedagogy* as theoretical framework and their two aspects of analysing is linked to functionally or critically:

- Analysing functionally: Learners analyse logical connections, cause and effect, structure and function.
- Analysing critically: Learners evaluate their own and other people's perspectives, interests and motives

When you create a virtual meeting with an expert as an instructor you need to design a clear learning objective in order to let the student engage in the aspect of *analysing critically*. Sometimes experts combine interactive direct instruction with a virtual field trip to develop background knowledge. There are also examples when educators invite a guest speaker or interview local stakeholders to broaden perspectives on lesson content, but this will not automatically lead to critical framing. When experts are joining as an instructor in a design element it is recommended that difficult concepts are broken down through “chunking” and interconnecting points, rather than trying to memorize large amount of information.

The preliminary results indicate that there is a need for a training module in how to use video conferencing with an expert to differentiate learning processes in STEM subjects. My belief is that in the National Agency for Education should develop or endorse existing initiatives similar to the portal for Skype in the Classroom.

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## *Playful Development of Mathematical Thinking Skills in Primary and Secondary School with the Logifaces STEAM Education Toolkit*

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Keywords: Logifaces, STEAM, mathematical thinking

Logifaces (<http://logifaces.com/>) is an award-winning geometric puzzle from the Finland-based ExperienceWorkshopSTEAMNetwork's ([www.experienceworkshop.org](http://www.experienceworkshop.org)) educational collection. The Logifaces implements 3D-shapes in providing logical and creative challenges through simple problem-solving activities for various educational contexts and age groups.

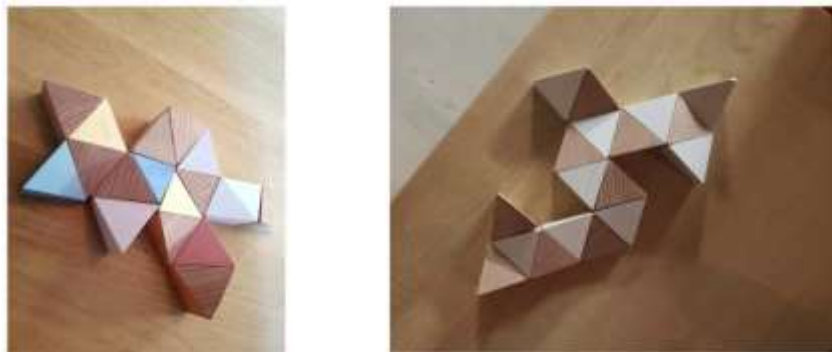


Figure 1. Logifaces toolkit made of wood and concrete. Photo: Matias Kaukolinna.

Currently, an international group of educational experts, including teachers of different subjects, researchers, and designers from Austria, Finland, Hungary, and Serbia, are collaborating on the "Logifaces: analogue game for digital minds".

Erasmus+ project to extend the applications of the game from mathematics to further domains. Logifaces successfully inspires playful and embodied learning experiences even in traditional classroom settings, and offering apparent connections between mathematical problem-solving and design- or art-based challenges. The toolkit has the potentials to develop spatial, visual, and computational thinking and to engage students in multidisciplinary learning projects to explore various phenomena from scientific and artistic perspectives and improve key competences. We



introduce the main goals and the first results of the Erasmus+ project and the main components of the Logifaces STEAM toolkit in the presentation.

Although the Logifaces toolkit is based on geometry and combinatorics, the idea comes from an architectural-design background. The first paper prototype of Logifaces was created by two Hungarian architects, Zsanett Benedek and Dániel Lakos, in 2013. Logifaces received the Hungarian Design Award, and it was the finalist of a game design competition juried by Ernő Rubik, the inventor of the Magic Cube. There are different variations of Logifaces game, with or without colors, made of wood or concrete, and tracks for a marble run, or a candlestick, called Logifaces Miracle Edition (Figure 1).

The game usually comes in the set of nine or sixteen different truncated triangular prisms. Each triangular truncated prism is distinguishable through the height of the three vertices that can be one, two, or three units. The goal is to arrange the modules next to each other in order to build a continuous surface without any disruptions. Even though it sounds simple, the game is logically quite demanding, since there are millions of variations. In Figure 2, we can see three Logifaces of different heights arranged in a wrong (a) and correct (b) way of assembling.



Figure 2. The "wrong" and "correct" ways of assembling three different Logifaces blocks. Photo: Matias Kaukolinna.

Logifaces can be a useful tool in geometry learning, as it supports the hands-on discovering of 3-dimensional geometric objects with certain characteristics. Students are encouraged to observe, touch, arrange, analyze and assess the shapes by thinking logically and creatively, thus learning to identify main geometrical properties of each element in the set, examine the modules' orientation, switch between 2-dimensional and 3-dimensional thinking, considering variables related to planes and volume, develop geometric concepts and acquire related geometrical vocabulary. The playful and embodied aspects of learning with Logifaces contribute to developing the social dimensions of learning through collaborative problem-solving. Logifaces can inspire both mathematical and artistic creativity and help students to gain a deeper understanding of geometric forms.

# *Creative tools to talk to students about the climate change*

Emma Abbate

Liceo Statale Alessandro Manzoni Caserta Italy, University of Naples L'Orientale

Keywords: Gamification, creative thinking, web tools

## **Introduction**

How to bring the topic of climate change and environmental sustainability into the classroom? To meet this challenge, this poster presentation illustrates an educational project that aims to foster students' ability to observe and interpret global processes in order to understand their evolution and scope, but above all to highlight their interconnection.

The poster describes activities and free pedagogical resources that provide teachers with useful tools to address the topic of climate change in the classroom.

In the poster presentation will be discussed examples of game based approach to climate change topic in the context of the classroom through famous video games such as Minecraft or the use of theatre, which has always been a tool to know the world and to address crucial issues in a more direct and understandable way. Maxwell Boykoff, associate professor of theatre at the University of Colorado, in his research on the combination of climate change and comedy, shows that creative techniques used in theatre are a useful tool for communicating climate change (Boykoff, 2018). Boykoff states that communicating climate change to young people using humour is "magical" and humour can make the science of climate change more accessible.

The poster will also illustrate pilot projects which combine the appeal of social networks with competition in completing environmental "missions" (Lee et al., 2013).

Practical and concrete examples, best practices, challenge and problem-solving tasks will be described to inspire teachers to a gamified approach to climate change in their classes.

## **Research methods**

Observation, action research, surveys.

## **Results**

When the aim is to stimulate students to be more respectful, aware and responsible about the environment, gamification seems to be an effective tool and a good educational approach.

One of the benefits of gamification systems is that they often influence the action of a community by being able to exploit the "pressure" that the group exerts on the individual.

Trough game activities and tasks based on challenge to reach an aim in a collaborative way, a space is created for the promotion and approval of ecological behavior.

The effort required to adopt a new sustainable habit towards environment vanishes when this process happens playing or having fun.

The use of a gamified learning system is more effective in producing change and maintaining it over time (Munoz Organero, Corcoba Magana, 2014).

## Conclusions

In conclusion, it is worth noting that these types of projects can be effective tools for producing practical change. The data collected through surveys and interviews with students show a greater concern and more heartfelt social support for climate policies.

Educational games have empirically proved to be able to concretely move students' consciences and induce changes in behaviour, in fact it is an implication of gamification to influence the intrinsic motivations of the game arising from the desire to achieve goals, compete, win, feel capable (Schoech et al., 2013).

It is therefore possible to exploit the pulling power of games to improve health, well-being, increase donations, limit environmentally destructive behaviour.

## Acknowledgments

I am grateful to Professor Maija Aksela from Helsinki University for the wonderful opportunity of professional growth that she gave me last summer when I participated to the Climate Change forum summer camp: the creative environment, full of ideas and educational stimuli, has strongly increased my interest in the application of catching teaching strategies for teaching climate change in my classes.

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Schoech, D., Boyas, J., Black, B., & Elias-Lambert, N. (2013). Gamification for Behavior Change: Lessons from Developing a Social, Multiuser, Web-Tablet Based Prevention Game for Youths. *Journal of Technology in Human Services*, 31(3), 197-217

## Poster session 2: New research-based approaches to STEAM

**Time: Thu 4.6 June at 15:30 pm**

### *Integrated STEM Activities for Developing Design Thinking in Egypt*

Ahmed Hamman<sup>1</sup>, Martin Lindner<sup>1</sup>, Heba EL-Deghaidy<sup>2</sup>

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<sup>2</sup>American University in Cairo, Egypt

Egypt need to strengthen STEM (Science, Technology, Engineering, and Mathematics) education in order to achieve a developed nation that is able to face the challenges and demands of STEM-driven economy by 2030. There is a need to developing design thinking skills (DTS) allowed students engagement in STEM education. The purpose of this research was determining the effectiveness of an integrated STEM unit -Simple Machines- for developing DTS in science education for the sixth-grade students at official language school in Egypt. The research sample was (35) sixth-grade students at Cairo government as an experimental group. Quantitative analysis of pre/post design thinking scale and a rubric to assess students DTS. Results showed that there is a statistically significance difference between pre-post applications of the experimental group in design thinking scale as a whole and their sub skills (empathy, define, ideate, prototype, and testing). The need to include integrated STEM activities, problem-based learning and draw from design thinking features to modify existing curricula in Egypt that allowed students to think more broadly about science content with STEM integration and be prepared for future careers.

### *Summer Code Club Petrila*

Cîndea Nicoleta and Gogea Alexandru

Constantin Brancusi Technical College Petrila, Romania

Promoting STEAM in education is quite a challenge itself, for me it would be an excellent opportunity to show different methods or ideas that our college and even the local community have had to adopt in order to transform major difficulties and uncertainties regarding the environmental reconversion of the former mining areas in opportunities. I have been teaching since 1986, so my area of expertise is focused on pupils, on the educational process. I have attended many professional

and professional training courses and since 1998. I have been working as a volunteer in various NGOs. Due to my personal skills, like entrepreneur, leader, manager, open minded, not to mention friendly, I have become a voting member CIVICUS. I have also good communication skills and a rather instinctive sense of gathering people, which I consider a valuable asset. I have been involved in international projects, I have had the opportunity to change my teaching method; as a logical consequence I became a Methodist teacher in Physics.

The main idea of the most recent on-going project is to recreate the former Petrila mine as a scientific cultural hub, to be more specific, Robotics oriented. One of my students, recommended by me, has been selected to the Robotic World Championship in Detroit USA, as a logical consequence I and other enthusiastic pupils, we have been able to initiate other students in the use of the microbit. So we have been able to win two prizes from Element 14 USA, through which we have offered 30 microbit botads and 10 Raspberry Pi boards to the local library. After receiving the 30 micro-bit placements, we started the mentoring classes and our students have won the first place in the second phase of the competition, where they received 10 raspberry pi plaques. Today the students have become themselves mentors for the newcomers/beginners. These awards have allowed a robotics club to operate at the city level, where all citizens can participate. Through another project, which has also implied the local library, we have purchased a graphic tablet and a 3d printer. All the interested citizens have now the opportunity to learn how to use those items. Starting this year Robotics has become a constant theme of our enthusiastic pupils, Robotics is now an optional that might be included in the college curricula. Through Robotics coding skills have been developed by the students from Valea Jiului. For the first time in the Petrila College, in the Jiu Valley, the passion for Robotics and new technologies is remarkable. Since a couple of years, in the pay-it-forward system, the high school students from Petrila have taught those from Petroani and, since then, this passion continues to expand.

### *Using computers to support education and learning*

Kalle Saastamoinen and Antti Rissanen  
National Defence University, Finland

The presentation explores the use, benefits, opportunities, and threats of computers to support teaching and learning.

Computers, tablets, the Internet and smartphones play a big role in our daily lives. Not surprisingly, their use has already become part of modern teaching practices. Their role will continue to grow. The use of the devices has the potential to achieve numerous advantages over the

so-called traditional teaching, such as information retrieval, educational interaction, up-to-date student activation, instant test feedback, visualization, material clarity, following/analyzing learning, free time, utilizing other content as part of teaching. Pupils' group work is interactive and compares things from many perspectives. Students learn to take responsibility for the solutions they present. Students learn skills that they can use extensively in their professional lives, which are often also dependent on the information technology they use (Barroso, 2019; Fouts, 2000; Hokanson & Hooper, 2000; Iskrenovic-Momcilovic, 2018). Modern technology makes it easy to support interaction and problem solving as part of the learning process, skills that also play a key role in the workplace.

Games, social media, streaming services, and other non-educational content can be seen as a threat to devices. These threats can be counteracted to some extent by placing filters on the devices used that limit what they can do with them. However, the limitation is problematic as it may also prevent access to educational content. On the other hand, if a student uses his or her own equipment, restriction is easily unethical and difficult to enforce. These threats can be countered by making the educational event so interactive and challenging that there is simply no time left for the 'extra'.

The disparate impact of device use can be seen as a threat, with the varying ability of users, students and teachers to use devices, to search for information and to operate in different environments. Discrimination also involves having students with different levels of hardware and software at their disposal. Both of these factors are influenced by pupils' background variables, such as parents' social status, wealth, and a variety of personality factors. The threats of inequality can also be seen as a positive opportunity to learn new things, an educational institution can provide the same tools for everyone, and technology can be used to support different learning styles. On the other hand, the cohesive ICT skills learned may balance the impact of parents' social status (Pagani, 2016).

The big problem with using technology is simply the inability of the technology. In addition, the belief in the superiority of technology as a solution to all problems is problematic. For these reasons, the pupil and teacher must continue to be able to solve problems even without a computer, tablet, Internet and smartphone.

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## *The Design of the Two-tier Test to Diagnose Student' Conceptual Difficulties about Heat and Temperature*

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Most work in science education points out that college and university teachers must take into account their students' alternative conceptions, which are erroneous, compared to scientific notions and which constitute an obstacle to understanding the scientific knowledge. However, it should be noted that the majority of teachers do not systematically consider the initial conceptions of their students (Tiberghien, 2002; Schmidt et al. 2006). They do not take them into account because of their insufficient or absent training in didactics, which does not allow them to use, among other things, a Piagetian type approach to identify them (Coppens and Munier, 2005, OECD, 2005). According to this observation, researchers worldwide are developing two-tier and three-tier tests that take into account the misconceptions of students listed in the review of the international literature (Chiu, 2007; Coppens et al. 2009; Métioui, 2019) and which could be used by teachers to fill these gaps. The present research pursues the same goal. It aims to present the design of a two-tier test to diagnose students' alternative conceptions about the concepts of heat and temperature.

Interestingly this category of the survey allows us to quickly identify the conceptions of students that cannot be identifying with the traditional evaluation as the multiple-choice questionnaire. Thus, in this communication, we will first present a review of the conceptual difficulties of students about the concepts of heat and temperature. Next, we will specify the approach used to construct the two-tier test. Finally, we will present the limits of such a tool for diagnosing student conceptions.

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### *Chemistry Education In The Anthropocene*

Merve Nur Yavuzkaya, Helen Hasslöf, and Jesper Sjöström  
Malmö University, Sweden

Over several decades, there have been many calls to transform chemistry education in order to promote learning and engaging students in chemistry. For example, conceptual understanding research gave its place to developmental approaches, namely, learning progressions. However, a lot of researchers stated the need for context-based approaches to make chemistry education more meaningful and relevant for students. Socio-scientific issues (SSI) oriented chemistry education, for example, can be considered as a contextual framing. However, this approach tended to offer more things to know, instead of providing a context for the students to engage in critical discussions about ecological, economic, and societal dimensions (Gilbert, 2016) of chemical pursuits. In consequence, this contribution aims to provoke a discussion on how chemistry education can be reframed in the Anthropocene and problematize systems thinking as a way of the Anthropocene aware chemistry education. It is argued that there is a need for rethinking chemistry education in the complex societies stemming from a noticeable human impact on chemical, biological, and geological systems in the Earth (Mahaffy, 2014). Acknowledging that human factor is responsible from the changes in the Earth systems more than before, we are being driven to an uncertain and a complex future (Guyotte, 2020; Stratford, 2019). Considering the role of chemistry in the global challenges, chemistry education is suggested to adopt a humanized approach including the role of human activity, socio-scientific issues, benefits-costs-risk analysis of chemical activities, e.g. by utilizing a cross disciplinary approach (Zowada et al., 2019). In addition, involving in chemical pursuits as scientists or citizens, requires taking quality of life and preserving environment into consideration (Sjöström & Talanquer, 2018).

In this presentation, systems thinking is problematized as a way of addressing global challenges through chemistry education and conceptualized as a way of acting on material world through sustainability perspective and decision-making processes (Mahaffy, Matlin, Whalen, & Holme, 2019). It is aimed to develop knowledge through the questions which living in a complex, uncertain era made visible: How can chemistry education be reconceptualized in the Anthropocene? How can systems thinking be infused in chemistry education?

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### *Can science make a difference when music education is the main goal?*

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Keywords: Music, scientific inquiry, sense experiences

## Introduction

In every instance of interdisciplinary collaboration there is the inherent question of who benefits. In the often proposed transformation from STEM to STEAM, a movement *from* something to something else is implied. In this perspective, it is tempting to conceptualize STEM as primary, and

“A” to be something that shall on some way enhance, broaden or provide new perspectives. Such thinking may lead us to ask: how can arts contribute to a “better” STEM education? However, this carries with it an inherent problem, namely that of instrumentalism, which has been problematized by scholars within the arts (Varkøy, 2013). For, why should arts accept being reduced to handmaidens of STEM? In the present project, we have sought to shift this balance and rather ask to which degree science can contribute to music education, on the terms of music education. This is done by seeking a common ground for science and music, namely sense/sensory experiences, more specifically the multisensory perception of flavor. For this project, it is important to find how science can make a difference so that music can truly benefit, rather than seeking superficial commonalities between the subjects. The scientific contribution to music should be experienced by the learner as credible, naturally present, and maybe even “needed”.

The described project is still in progress with research data presently being collected. Here we present our research questions, the conceptual thinking behind, and design of the project. Our main research question is

*How, if at all, can scientific thinking and practices related to multisensory perception contribute productively to music education, on the terms of music?*

We further break this down into the more specific questions

1. Which common knowledge between the subjects arise in this context?
2. Which possibilities and challenges are found?

## **Context and conceptual basis**

The project is conducted in an upper secondary school, involving a researcher, a teacher-researcher and 28 first-grade (16 years of age) music specialization students. A minimum criterion in interdisciplinarity is that there is a common interest, or overlap in knowledge or practices, between the involved subject domains. Herein, we find such overlap in that both science and music deal with human senses and sensory perceptions/experiences. Specifically, we draw on the phenomena multisensory perception and crossmodal correspondences (Spence, 2011), e.g. that we make implicit links across sensory modalities: red is often associated with sweetness, high-pitched sounds are associated with sour taste etc. Similarly, in music it is common to state non-musical references to describe the music, e.g. that the music reflects experiences of nature, certain works of art, literary texts etc. Thus, both sciences and arts have interests in active and deliberate sensory perceptions.

Thereby, sensory awareness is promoted by music through active listening (Østergaard, 2019), science through sensory science where human senses are used as measuring instruments for inquiry (Meilgaard, Civille, & Carr, 1999), and experience-based science/STEM education as advocated by e.g. Dahlin (2003).

## **Research design and methods**

The project draws on design-based research methods (Juuti & Lavonen, 2006). A teaching sequence was designed and implemented throughout one semester with weekly lessons of 90 minutes. Logbooks from participatory observation (written and recorded), reflective discussions between teacher and researcher, and students' written accounts and sound recordings constitute the empirical data.

### **The teaching sequence**

The teaching sequence is designed for the music subject “Listening” where students are to learn about active musical listening, reflecting on what they hear, and relate this to musical knowledge. The sequence is built gradually towards a final task where the students are to compose a soundscape to represent a specific flavor experience, and subsequently share this with their peers. The sequence includes systematic use of senses for data collection and analysis. As students analyze and reflect upon links between compositions and flavor sensations in each other's soundscapes, composition and listening is linked to sensory perceptions also from the side of science. Thus, science feeds constructively to musical creation.

### **Initial reflections and outlook**

We find that although there are obvious overlaps between science and music when taking departure from multisensory perceptions, it is as educators not easy to find truly productive approaches that are not perceived as “forced”. However, we have at the point of writing this abstract still not entered the final phase where the students are to compose their flavor-inspired soundtracks. We aim at presenting initial results as part of the conference presentation.

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### *Exploration of TDS students' choice of mathematical concept - a photography-based teaching intervention*

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Keywords: In-service teacher education, mathematics education,  
photography

## Introduction

The present work is part of a design-based research project, designing, analyzing and revising teaching activities through several cycles (Meier, Hannula & Toivanen, 2018). Multiple researchers have argued that mathematics education would benefit from a more prominent place of visualization (Arcavi, 2003, p.215; Munakata & Vaidya, 2012). In our earlier research we found that photographing seems to increase visual attention and can change the perception of the environment towards seeing it with a mathematical eye (Meier et al., 2018). The research questions are: Which mathematical concepts are identified when in-service teacher students engage in a photography-based activity? And secondly, how can the activity be revised for future implementations?

## Research methods

During an in-service training course, 44 teachers were reminded of the mathematical concepts of the Norwegian curriculum (numeracy, algebra, function, geometry, measuring, statistics, probability and combinatoric). Using their mobile phone, they explored the campus environment for objects having mathematical property. After taking ten pictures they discussed the potential mathematical content in groups. Based on one photograph and a chosen mathematical concept from the curriculum they were asked to design and conduct a task for their own students in classroom. The teacher's pictures, descriptions and reflections of the task were discussed in the course. Data were constituted by these photograph-task pairs. Potential mathematical concepts in the chosen picture were identified. Through a qualitative analyze of the written description of the task the chosen mathematical concept was related to the potential concepts.

## Results

Upon analysis of the photograph-task pairs, I found that the mathematical concepts identified by the teachers were dominated by the concepts of numeracy and geometry, even though there was potential for choosing other concepts as identified by the researcher. In geometry, tasks including basic two- and three-dimensional forms were dominant. Notably, none of the teachers identified, or chose to highlight, symmetry as mathematical concept.



Figure 1: Drain on the path

For example, a picture of a drain on the path (figure 1) was used to make a task about two-dimensional figures and counting. The apparent options for reflectional and rotational symmetry were not chosen. Is the reason a gap in teachers' awareness or knowledge of symmetry?

As the field of symmetry is known and accepted as an essential part of our culture and development of mathematics, teachers need to develop awareness for symmetrical relationships

(Dreyfus & Eisenberg, 1990). The strong connections to architecture and art, nature and science, make symmetry a highly suitable subject for context-based teaching.

Therefore, symmetry will be highlighted in the revision of the teaching sequence. Work by Farenga and Ness (2007) will be drawn on to design a sequence where architectural structures and patterns in the college environment will be photographed and various forms of symmetry described and identified. Suggestions for the revised design can be discussed in the presentation session.

## Conclusions

The area of numeracy and geometry (without symmetry) was most prominent in teachers' choices. As the potential for symmetry is obvious in many of the pictures, and the need for teaching symmetrical relationships is shown, future implementations will emphasize the perception of symmetry in the outdoor environment.

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## *Pre-service Teachers Views on their Campus Garden Based Teaching Practice*

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This study presents the 2nd grade preservice science teachers' reflection on a teaching practice in the campus garden that planned and organized by their classmates. They were interviewed about this practice and their teaching approaches for Garden-Based Learning (GBL). Outcomes showed that preservice science teachers believe they need more practice for outdoor teaching. They are feeling not well prepared taking the students outside the classroom.

## *Ecosystem Approach In The Content Of School Course Ecology*

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Key words: ecology, environmental education, pedagogy, ecosystem, anthropogenic factors

### **Abstract**

Discusses the content of a school course of ecology. The analysis of the existing approaches to school environmental education. It is proposed as the fundamental core of ecological content to examine the influence of anthropogenic factors on different ecosystems.

In the context of the aggravation of the ecological and economic crisis, it is necessary to return to the discussion of teaching ecology in schools, since the content of the course must be revised. Ecology should be considered as a biological science (Ricklefs, 1979), but the object of study is the ecosystem, the subject of study is the consequences and forecasts of the influence of various factors (abiotic, biotic, anthropogenic, etc.) on the components of ecosystems (dominant species). To prove the validity of this statement, should give the example that demonstrates the uniqueness of environmental knowledge on the one hand and the lack of development of the modern concept of the content of environmental education (training) on the other, in order to reveal the meaning of the content of ecology in the framework of basic general education. This example is noise pollution or noise. Unfortunately, most textbook authors (Ricklefs, 1979), and therefore teachers, consider noise pollution exclusively at the organizational level. Moreover, the consideration of the impact of



noise level is reduced to describing the harmful effects usually on human health. Of course, man is the dominant species if we consider urban ecosystems, but why is there no data on the influence of this factor on the dominant species of animals and plants in other ecosystems (forest, steppe, etc.). The situation is similar when considering chemical contamination. Textbooks are full of information (definitions and terms) of general biological, simultaneously duplicating the material of biology, physics, chemistry, etc.. For example, consider how one of the anthropogenic factors is discussed- radioactive contamination (Arustamov & Barkalova, Levakova, 2004; Mirkin, & Naumova, 1995; Yagodin & Argunova, Plyusnina & Morgun, 2008;). Students are offered a text of varying degrees of saturation with terms of a General biological nature, emotional coloring, and physical terms. To show of the influence of high doses of ionizing radiation on organisms of various species and humans are revealed, and the economic damage from accidents at nuclear industry facilities (the Chernobyl accident) is described. However, students can get similar information from the textbook of physics, biology, and chemistry (Myakishev&Bukhovtsev, Charugin (2014)). A new school textbook on ecology will require at a minimum, it will be necessary to systematize data on the impact of various environmental factors on the dominant species of different ecosystems, study concentration and dose dependencies, study migration processes entering ecosystems, take into account the combined effects, and assess the ecological and economic risk of the consequences of changing ecosystems for the population.

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