LUMAT Research Symposium

Engaging learners in math and science through modern technologies

June 9-10th, 2021

Conference Book

Organized by
LUMAT Science Research Forum
&
Finnish Mathematics and Science Education Research Association

LUMA-KESKUS SUOMI
LUMA-CENTER FINLAND
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Welcome to the 11th LUMAT Research Symposium

International LUMAT Research Symposium gathers teachers and researchers from around the world to learn, share ideas and collaborate. The theme of the symposium 2021 is "*Engaging learners in math and science through modern technologies".* The symposium will concentrate on teaching, learning and assessment approaches, which utilize modern technologies in math and science education to engage learners of different ages.

This year's event is the second symposium organized online. Through the international event, we hope that scholars throughout the world can connect and share their ideas with colleagues.

The symposium consists of keynote talks and oral presentations. The two invited keynote talks discuss engagement in science, mathematics, and technology education as well as the use of modern technologies.

Oral presentations concentrate on the broad topics of science, mathematics, and technology education and inspire us how to engage students to learn through modern technologies. Extended symposium abstracts can be submitted to a *LUMAT* special issue on the symposium topic.

Welcome to our virtual symposium organized by *LUMAT Science Research Forum and Finnish Mathematics and Science Education Research Association!*

Kind regards, the organizing committee of LUMAT Research Symposium:

Dr. ***Maija Aksela****, professor, director, LUMA Centre Finland, University of Helsinki*

Dr. ***Jan Lundell****, professor, director, Central Finland LUMA Centre, University of Jyväskylä*

Dr. ***Veli-Matti Vesterinen****, university lecturer, president of the Finnish Mathematics and Science Education Research Association, University of Turku*

Dr. ***Pasi Nieminen****, senior lecturer, University of Jyväskylä*

Dr. ***Jaana Herranen****, research coordinator, LUMA Centre Finland, University of Helsinki*

Dr. ***Johannes Pernaa****, university lecturer, managing editor of LUMAT journal, University of Helsinki*

B.Sc. ***Veera Uusi-Äijö****, research assistant, University of Helsinki*

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Program

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Thu 10.6 morning	**09.00–10.00**	**Oral presentations 1**
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	10.30-11.30	**Keynote 2**
	11.30–12.30	Break
	12.30–14.00	**Oral presentations 2**
Thu 10.6 afternoon	**14.30-15.30**	**Oral presentations 3**
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	16.00-16.15	**Ending words**
	16.15 -->	**Get together: possibility to discuss with peers**

*Schedule follows Finnish time (UTC+3)

Keynote talks

Keynote 1: Jari Lavonen
Title: Engaging secondary students in science learning through emphasizing the use of scientific and engineering practices in Finnish science classrooms
Chair: Maija Aksela
Time: Wed 9.6 June at 10.00 am

Keynote 2: Angela James
Title: Opportunities and Possibilities for learning Science and Mathematics in the Context of Modern Technology: Interrogating research reports, studies, social networks and creative writings in the South African Education sector
Chair: Jan Lundell
Time: Thu 10.6 June at 10.30 am

Oral presentation sessions

Session 1: Supporting students STEM identities and development of modern skills *STEM education needs to provide students with skills that are necessary for 21st-century working requirements. This session concentrates on how to realize and support students STEM identities in STEM education and gives an example on how to teach programming in schools.* ***Chair:** Jaana Herranen* **Time: Thu 10.6 June at 9.00 am**	
Title of the presentation	**Presenter**
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Teaching programming in Finnish secondary education: a case study	Markus Norrby, Niklas Palmberg & Ray Pörn
Session 2: Engaging students with virtual materials and platforms. *STEM education has the potential to engage students` with virtual materials and platforms which students use in their everyday lives. This session concentrates on the benefits of using virtual platforms and technologies in STEM education and gives some examples on the matter.* ***Chair:** Johannes Pernaa* **Time: Thu 10.6 June at 12.30 pm**	
Title of the presentation	**Presenter**
Engaging Youth in chemistry through TikTok videos	Vilja Kämppi, Ida Koskinen, Johannes Pernaa & Maija Aksela
Engaging Preservice Chemistry Teachers by animations	Jan Lundell & Sevil Akaygun
Development of sustainable intervention strategy for waste management in schools	Lettah Sikhosana & AV Mudau
Session 3: Examples of how to overcome challenges in STEM education. *STEM education can overcome modern day difficulties by developing new strategies and insights. This session will present a couple of examples of new strategies and insights in the field of STEM education.* ***Chair:** Pasi Nieminen* **Time: Thu 10.6 June at 14.30 pm**	
Title of the presentation	**Presenter**
Teacher Support of Collective Argumentation in Mathematics Classrooms: Insights from an After-School Program	John Francisco
A Physics Lab in Your Pocket: Physics Olympics Go Online	Marina Milner-Bolotin & Valery Milner

Keynote talk abstracts

Engaging secondary students in science learning through emphasising the use of scientific and engineering practices in Finnish science classrooms

Jari Lavonen

The University of Helsinki, Helsinki, Finland

Abstract

Policy documents have suggested that school science should represent real scientific and engineering practices in order to better engage students in science learning. A two-year professional development project (PDP) or research practice partnership was organised for supporting science teachers (N = 25) to plan teaching modules, which emphasised the use of scientific practices in the context of project-based learning (PBL). These modules were designed according to new national core curriculum, which emphasises students' active role in collaborative learning and participation in scientific and engineering practices. Through employing these activities, students can create a set of tangible products, like graphs and tables. These products, shared artefacts or external representations, support students' collaboration and modelling activities. PDP outcomes were determined by analysing how the designed teaching modules supported students' engagement and learning. Experience sampling method (ESM) and a cognitive test were used as data-collection methods. The data showed that the level of engagement increased between the first and second year. The students in a PBL class gained better learning outcomes than in a control class. After the second year, the teachers emphasised in an interview that goal orientation, collaboration between the teachers and researchers, reflection and, moreover, their own active and contextual learning during the PDP, supported their learning. Moreover, they spoke about the importance of employing a research orientation to improve educational practices, and the role of formal training, such as workshops

Author bio

Dr. Jari Lavonen is a Professor of Physics and Chemistry Education at the University of Helsinki, Finland. He is a director of National Teacher Education Forum and member of the steering committee of the Finnish Education Evaluation Centre. He is a visiting professor at the Michigan

State University and University of Johannesburg. He has been the head of the Finnish Graduate School for Research in Mathematics, Physics and Chemistry Education. He has been researching science and technology education and teacher education for the last 31 years and his main research interests are science and technology teaching and learning, curriculum development, teacher education and use of ICT in education. He has been responsible for PISA 2006 Science in Finland and national level assessment in lower and upper secondary Physics and Chemistry. He has published altogether 150 refereed scientific papers in journals and books, 140 other articles and 160 books for either science teacher education or for science education. He has been active in international consulting, for example, involving the renewal of teacher education for example in Norway, Peru and South Africa.

Opportunities and Possibilities for learning Science and Mathematics in the Context of Modern Technology: Interrogating research reports, studies, social networks and creative writings in the South African Education sector

Angela James

University of KwaZulu-Natal, Durban, South Africa

Abstract

If South Africans are to participate in the knowledge economy, every effort must be made to prevent social exclusion, stated by the President in 2001. 2021, in the time of COVID, many inequalities across the schooling, higher education and community organisation settings are now, glaring in sight. Schools have been forced into a digital space evident from the digital platforms and online teaching methods employed through cellphone, radio, television and the internet. This article addresses the question: what Information and Communication Technologies (ICTs) messages are in reports, research studies, social networks and creative writings? How are/may these messages be used for opportunities and possibilities for enhancing learning in Science and Mathematics? An interpretive, qualitative, multiple case study of selected Education ICT content sources. Descriptive Content Analysis presented categories of messages of learnings, challenges, opportunities and possibilities. The disruptive time and space offers opportunity to improve the quality of education by creating enriching learning and teaching environments, the central role of teachers as creators for enriching teaching and learning environments and the importance of parent engagement in their children's learning.

Author bio

Angela James is a partner and mother to four amazing children. She graduated from the University of Pretoria with a PhD in Curriculum and Instructional Design and Development. She has over 30 years teaching experience in the schooling, tertiary and Adult Education sectors. She currently works as the Academic Leader for Community Engagement and is Senior Lecturer - Science Education in the School of Education, University of KwaZulu-Natal. She concentrates on research and Service-Learning for undergraduate students, Inquiry-based teaching and learning in the Foundation Phase and other phases, Science curriculum related areas (theory and practice), Professional development of teachers - construction and use of phronesis, Environmental Education, Science - race and ethnicity, and Indigenous Knowledge Systems. Her skills and expertise include teaching and learning, teacher education, assessment and curriculum.

Abstracts of the oral presentation sessions

Session 1: Supporting students STEM identities and development of modern skills

Time: Thu 10.6 at 9.00 am

Realizing and supporting student STEM identities: A portraiture approach

Elizabeth Saville

The University of British Columbia, Canada

Introduction

The learning cultures students experience in secondary science, technology, engineering and math (STEM) classrooms establish and sustain conditions for students to develop conceptions about who can do STEM and who belongs in STEM communities. This research aims to investigate and analyze how student's construction of positive identities in and through STEM high school learning environments might further inform research into supporting STEM educators in creating cultures of learning that challenge perceptions of who can succeed. This study seeks to address the following research questions: (1) In what ways do diverse groups of students describe their STEM identity formation and how these have been positively influenced through STEM classroom cultures? and (2) How might a richer awareness of students' STEM identity formation offer insights for educators to build learning cultures that recognize and support a diversity of STEM identities?

Context

It is well understood that historical western STEM education has been socially, politically and culturally informed and that seeing oneself as a rightful member of STEM communities may be at odds with diverse understandings of what success looks like in STEM (Calabrese Barton & Tan, 2019). A noted lack of women, minorities and persons with disabilities in STEM programs and careers related to physics, engineering, technology and computer science suggests continued urgency in exploring why some students remain excluded (National Science Foundation, 2019; Statistics Canada, 2019). Studies indicate that issues of representation in STEM are deeply connected to foundational and complex issues around identity (Nasir & Vakil, 2017). STEM identity is grounded in the extent to which individuals see themselves as a part of and feel accepted in STEM communities (Kim et al., 2018). It includes perception of oneself as well as recognition by others as a STEM person which accounts for both how individuals might make meaning out of STEM

experiences and how society might structure possible meanings (Carlone & Johnson, 2007). The lens of identity in STEM offers potential for better understanding the complexities of making meaning and purpose through STEM learning experiences and for how student's learning and agency might be supported by situating all diversities of students as legitimate members of STEM communities (Avraamidou, 2020).

Methodology

The qualitative method of portraiture will be used to capture stories of STEM identity formation from a diverse group of secondary students (n=6) in the provinces of British Columbia and Ontario in Canada. Developed by Lawrence-Lightfoot and Davis (1997), portraiture is based on an understanding that narratives are primary and valid structures through which personal and professional identities might be framed, sustained and shared (Davis, 2003) and draws upon aspects of ethnographic, narrative, phenomenological and arts-based methodologies (Travis, 2020). In this study, portraiture will be used to construct complex, authentic narrative portraits of secondary student STEM identity formation within the context of STEM classroom learning cultures. Portraits will explore what students understand as their STEM identity and the forces, factors and conditions that contribute to forming, maintaining, and also challenging what they think it means to be a STEM person. Data collection will include narrative questionnaires, classroom observations, focus groups and interview conversations. This study is framed from an explicitly positive approach to examine what is working well for students in supporting their positive STEM identity formation, an alternate and complementary approach to identity research. Desired Outcomes It is hoped that portraits developed from student accounts of STEM identity formation might illuminate ways in which STEM learning cultures have best supported STEM identity. It is anticipated that findings will contribute to knowledge and practices of STEM educators in recognizing the importance of STEM identities, the diversity of these identities, and how to create conditions for a multitude of STEM identities to thrive in classrooms.

Conclusions

This research serves as a unique and important contribution to STEM identity research as it attends to the intersectional identity work of diverse students in recognizing and perceiving oneself to be a rightful member of STEM communities through a positive lens. New knowledge and tools that results from this research will be of interest to those in the educational community seeking innovative ways of improving the STEM learning experience of all students.

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Teaching programming in Finnish secondary education: a case study

Markus Norrby[1], Niklas Palmberg[2] & Ray Pörn[3]

[1,2]Åbo Akademi/Vasa Övningsskola, Finland & [3]Yrkeshögskolan Novia, Finland

Aim

Teaching programming in Finnish secondary education in collaboration with tertiary education: a case study Markus Norrby (mnorrby@abo.fi, Åbo Akademi University/Vasa övningsskola) Niklas Palmberg (Åbo Akademi University/Vasa övningsskola) Ray Pörn (Novia University of Applied Sciences) Introduction Current curriculum reforms in Finland are pushing for more collaboration between secondary and tertiary education. At the same time there has been a concentrated effort to introduce the concepts of computer programming throughout the primary education curriculum, but so far similar efforts in secondary education have been limited. In an effort to explore the possibilities of using collaboration with tertiary education as a foundation and motivation for studying programming in secondary education a pilot program has been developed, implemented and evaluated at Vasa Teacher Training School at Åbo Akademi University, in collaboration with the Department of Engineering at Novia University of Applied Science and the Faculty of Education at Åbo Akademi University.

Research settings

In phase one of the study students from the secondary school Vasa övningsskolas gymnasium (VÖS), together with one teacher, took part in the regular first year coding course at the Department of Engineering at Novia University of Applied Science (Novia). The course introduces the concepts of programming in the C++ language using Microsoft Visual Studio in a basic 2 ECTS module. The VÖS students took also took part in the final examinations and those who passed were awarded a certificate of study points from the Open University section of Novia. All VÖS students were awarded one voluntary secondary course point for their participance. The second phase of the study meant that a course with the equivalent content was taught at VÖS, adapted especially for the secondary education context. This made the logistics of taking part in the course much simpler, as the course could be adjusted to the schedule of the VÖS students and it was not necessary to travel (the relatively short distance) to the university area. The students were again awarded one voluntary secondary course point with the option of writing a test at Novia to receive ECTS. A third phase of the study is being planned where the course is modified according to the 2021 curriculum reform and aimed at slightly younger students.

Results

The results clearly show that secondary education students with the motivation to choose programming as a voluntary course are capable of completing it at the same level as the tertiary students. The adaptation of the Novia course for VÖS required only minimal adjustments to level, structure, content and didactics. The students' results are still very strong and the general feedback very positive. But the weakness of the set up is equally clear in the fact that a relatively small group of students chose the optional course in both phases of the study, there was a significant number of drop outs, and especially in the second phase there was minimal interest in making even a small extra effort to gain ECTS. Preliminary analysis of the pre-course and post-course surveys with the students indicate that this weak interest is at least partly connected to programming not being a specified subject evaluated in the national matriculation exam, which in Finland is the main route to tertiary education. It is the strong opinion of the authors that a national curriculum for programming in secondary education should be developed as soon as possible in Finland and that this subject should be evaluated in the national matriculation exam in a similar manner as the other sciences.

Acknowledgements

The authors express their gratitude to Högskolestiftelsen I Österbotten and Svenska tekniska vetenskapsakademien i Finland for financially supporting the project.

Session 2: Engaging students with virtual materials and platforms

Time: **Thu 10.6 at 12:30 pm**

Engaging Youth in chemistry through TikTok videos

Vilja Kämppi, Ida Koskinen, Johannes Pernaa & Maija Aksela
University of Helsinki, Finland

TikTok videos can be a way to engage youth in chemistry. This presentation describes preliminary results of a case study, in which it has been studied

i) what kind of topics can engage students in chemistry?

ii) how can they engage youth to think in chemistry?

It has been published 15 TikTok videos until this, and analyzed frequency of users, comments and questions through content analysis. These results show that the videos engage youth well in chemistry. Opportunities and challenges of the TikTok videos will be discussed.

Engaging Preservice Chemistry Teachers by animations

Jan Lundell[1] & Sevil Akaygun[2]
[1]University of Jyväskylä, Finland & [2]Bogazici University, Turkey

This talk will focus on using static and dynamic models and visualizations to support hands-on learning of chemical concept. A combination of drawing, animating and discussions employing models could help students to understand the connection between chemical structural changes with observables. The analysis of representations used and applied reveals a diversity of conceptions about the origin of the phenomenon studied. This approach also gives educator the possibility to react on appearing naive conceptions or misunderstandings. in a constructive manner. In addition, such an approach extended into teacher education would give an active hands-on ownership experience of formulating mental models of chemical concepts.

Development of sustainable intervention strategy for waste management in schools

Lettah Sikhosana & AV Mudau
University of South Africa, South Africa

Aim

The aim of the study is to develop and implement sustainable intervention strategies for solid waste management in schools in Nkangala District, Mpumalanga province. The interests of the study are based on anecdotal evidence, as the researcher observed that some of the schools and classrooms in Nkangala district are polluted with solid waste and there are no (or minimal) waste management initiatives that are implemented to manage waste effectively.

Research Methods

This is a qualitative interpretative multiple case study design embedded within a social constructivist theoretical framework. Three intermediate schools under Thembisile Hani local municipality, Dr JS Moroka local municipality and Emalahleni local municipality will be purposefully sampled based on quintile 1, 2 and 3. Targeted participants will be learners, teachers,

school principals, general workers and school governing body members. Qualitative data will be collected through semi-structured interviews, focus group interviews, observations, diary and open-ended questionnaires. Pseudonyms will be used to protect the participants' identities. Qualitative data will be analysed using a typology approach based on the research questions, categories and themes as well as the theoretical and conceptual frameworks underpinning the study. This is not a comparative study as the researcher seeks to develop and implement sustainable intervention strategies that accommodates each school. As a result, all data collected will be analysed as a single case.

Session 3: Examples of how to overcome challenges in STEM education

Time: **Thu 10.6 at 14.30pm**

Teacher Support of Collective Argumentation in Mathematics Classrooms: Insights from an After-School Program

John Francisco
University of Massachusetts Amherst

Teacher Support of Collective Argumentation in Mathematics Classrooms: Insights from an After-School Program There is documented evidence that promoting argumentation in mathematics classrooms is challenging for mathematics teachers. This study reports on the experience of six elementary school mathematics teachers in a three-year after-school program where they had the opportunity to facilitate research sessions on students' development of mathematical ideas, reasoning, and justification. The study examines the teachers' strategies for supporting students' development of mathematical arguments as students worked collaboratively on challenging mathematical tasks and aspects of teacher mathematical knowledge that influenced teachers' ability to effectively support argumentation in mathematics classrooms.

A Physics Lab in Your Pocket: Physics Olympics Go Online

Marina Milner-Bolotin & Valery Milner
University of British Columbia, Canada

For more than 40 years, the University of British Columbia (UBC) Department of Physics and Astronomy and the Department of Curriculum and Pedagogy have been organizing an annual hands-on science event for secondary school students: UBC Physics Olympics (Liao, McKenna, & Milner-Bolotin, 2017; Milner-Bolotin, Liao, & McKenna, 2019). The event draws hundreds of students from all over British Columbia to UBC campus. They participate in hands-on physics team competitions, including physics labs, Fermi questions, multiple-choice "Quizzics", and a pre-built event that requires students to construct a home-made apparatus to solve a challenge posted a month in advance. This event offers students a unique opportunity to experience hands-on science at a premier Canadian university. In 2021, due to the COVID-19 pandemic we moved UBC Physics Olympics online (UBC Department of Physics and Astronomy, 2021). The virtual UBC Physics Olympics involved two experimental tasks that the students had to perform at home using their smartphones as scientific instruments: to determine (1) the acceleration of a free fall and (2) the speed of sound in air at 0oC. Using a free app, called "phyphox" (Staacks, Hütz, Heinke, & Stampfer, 2018; Staacks et al., 2019) and a number of sensors available on a regular smartphone, students designed experimental setups, collected and processed data, and analyzed experimental uncertainties. The teams submitted their results in the form of a video report and a data spreadsheet. Despite the virtual character of the event, the home lab part of the competition was a big success, as demonstrated by the multitude of creative approaches implemented by the students in solving these experimental challenges. The lesson learned from this event will have implications not only for virtual science events, but also for regular classroom science teaching. Smartphones can become powerful tools to make science more engaging to secondary and post-secondary students. You can view the 41 ½ UBC Physics Olympics award ceremony online: https://physoly.phas.ubc.ca/ .

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