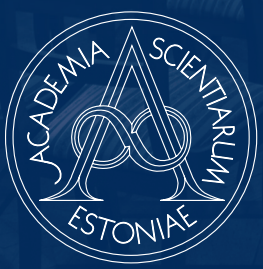
INTERNATIONAL EXPERT SEMINAR:

IMPACT OF RESEARCH IN SCIENCE EDUCATION

ADDRESSING THE NEED FOR A KNOWLEDGE-BASED SOCIETY

30 September 2021
Estonian Academy of Sciences
Tallinn, Estonia



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of Science Career Awareness” (SciCar)

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FOREWORD

The idea of, and the need for, research in science is well known. Today, the world is coping with the covid-19 situation, putting much reliance on the use of research-developed vaccines. Yet as an aspect of human nature, there are persons, for whatever reason, who reject such an approach. To relate to awareness, conceptualisations and person interactions research also needs to focus on educational thrusts and hence the field of science education. In a changing world, research in science education seeks not only to embrace advances in science, but also the manner in which educational advances can be applied in a changing scientific world.

This seminar reflects on research endeavours in the field of science education, bringing together well known and eminent science education researchers around the world to highlight different directions in how best to overcome the gaps existing between students' needs and science teaching, between the education for science teachers and the changing societal expectations and between the science research community and advancements in science education research. This seminar seeks to address science education researchers, PhD students, science teachers and science teaching staff in Estonian Universities as well as science education policy-makers and funding bodies. It is particular addressed to science education research and policy-makers and is intended to promote suggestions on how different parties can work together to support advancement, from a science education perspective, for a future knowledge-based society.

Miia Rannikmäe
Professor of Tartu University
Coordinator of SciCar project

30 SEPTEMBER 2021

Chair:	Prof. Miia Rannikmäe, University of Tartu
10:00–10:30	Arrival. Welcome coffee
10:30–11:00	*Opening words*. Tarmo Soomere, the President of the Estonian Academy of Sciences. *Introduction of the programme*. Prof. Miia Rannikmäe, University of Tartu
11:00–11:45	*STEM Education as a Paradigm Shift: What Research says about STEM Education* Professor Do-Yong Park, Illinois State University, USA
11:45–12:15	*A Research-driven View on Science Teacher Education*. Prof Jari Lavonen, University of Helsinki, Finland
12:15–12:45	*Research in Science impacting on Science Education*. Prof Ron Naamann, Weizmann Institute of Science, Israel
12:45–13:30	Lunch
13:30–14:00	*What does Research in Science Education say about students learning?* Dr Rachel Mamlok-Naamann, Weizmann Institute of Science, Israel
14:00–14:20	*How does Research in Science Education support the Practicing Science Teacher?* Helen Semilarski, PhD student, University of Tartu; Biology teacher, Tartu Miina Härma Gymnasium
14:20–14:50	*Overview of Research-driven, Paradigm Shifts in Science Education*. Visiting prof Jack Holbrook, University of Tartu
14:50–15:00	Concluding remarks
15:00–15:30	Closing reception (all participants)

A BRIEF BIOGRAPHY OF THE PRESENTERS AND ABSTRACTS

PROF. MIIA RANNIKMÄE

Tartu University
Head of the SciCar project
Chair of the seminar

Miia Rannikmäe is professor in Science Education and the head of the centre for Science Education in the Institute of Earth and Life Sciences within the University of Tartu Science and Technology faculty. She has considerable experience in science education in Estonia, Europe and worldwide (Fulbright fellow – University of Iowa, USA). She has a strong school teaching background, extensive experience in pre- and in-service teacher training and has strong links with science teacher associations worldwide. She has been a member of an EC high-level group associated with the publication of a 2004 report on 'Europe needs more Scientists'. Her research interests cover areas such as cognitive learning in sciences, relevance of science education, scientific and technological literacy, context-based teaching in inquiry based science classroom. She has published over 160 articles (47 articles in international journals, 20 articles in books).

Illinois State University, USA

PROF. DO-YONG PARK

Professor Do-Yong Park is a Fulbright Scholar and Fulbright Specialist of STEM Ed. within the School of Teaching and Learning in the College of Education at Illinois State University, USA. For the last 20years he has taught undergraduate, masters' and doctorial courses while also offering online courses at the University of Helsinki and the Korean National University of Education. He has been the author of a number of international journal articles and written two book chapters and has evaluated US national science foundation grant proposals. He has run numerous workshops in Finland, as well as African and Asian countries and received several research grants, both from the US and overseas. At present he is the president of the Global Educational Organization (GEO), a non-profit organization currently involved in a vocational program that trained high school graduates in Cambodia. He has been the co-chair of a teacher education special interest group for comparative and international education and society (CIES), a program evaluator for UNESCO ODA projects in sub-Sahara Africa countries and served on a US national science foundation review panel covering science education included STEM education. He currently serves on the University's academic planning committee, and the University research council.

STEM Education as a Paradigm Shift: What Research says about STEM Education

One key concept in STEM education is 'integration'. Integration is not new and can be traced back to the 19th century. Biochemistry was established as a specific scientific discipline in the 19th century and Molecular biology was

established as an official scientific discipline in the 1930s. Allegedly, these two new disciplines are deemed as a paradigm shift. In this case, integration is not just combining the two, but going beyond the border line of each discipline and creating a new area of study. After World War II, since the 1950s, science in the US returned to its unique and single area of study without much dialogue on integration. However, in the 1990s, integration rekindled attention to STEM education as a new discipline area. It took more than two decades to initiate STEM education, bring the STEM reform to 'scale' and to sustain and evaluate STEM education reform in the U.S. Today, based on a plethora of research-based evidence, STEM education has been infused into the 'school curriculum' based on research inputs into the Next Generation Science Standards, published in 2013 and the paradigm shift began in science education.

University of Helsinki, Finland

PROF. JARI LAVONEN

Dr. Jari Lavonen is a Professor of Science Education at the University of Helsinki, Finland. He is currently a director of the National Teacher Education Forum and chair of the Finnish Matriculation Examination Board. He has undertaking research in science and technology and teacher education for the last 31 years. His publications include 150 refereed scientific papers in journals and books, 140 other articles, and 160 books on education for science teachers and science education.

A Research-driven View on Science Teacher Education.

In the presentation, the new directions of Initial science teacher education are analysed. Initially science education research outcomes and their potential influence on science teacher education are considered, especially focussing on outcomes related to learning, engagement, and coherence of science education., New directions are analysed in the frame of research on teacher knowledge and, more broadly, research on teacher education. Several research points of view are raised, e.g., research on domains and the origins of teacher knowledge, the coherence of teacher education programmes and the role of university pedagogy research. Moreover, the role of research in science teacher education is discussed. Finally, competences teachers to promote learning for the future in science classrooms is considered emphasising the learning of ‘transversal’ competences. Based on these three views, aims for future science teacher education are outlined.

PROF. RON NAAMAN

Weizmann Institute of Science, Israel

Professor Ron Naaman is an eminent scientist in Experimentalist in Chemical Physics. His research is highly interdisciplinary and combines hybrid organic-inorganic systems with sophisticated physical measurements that are often applied to systems containing bio-molecules. Published more than 300 reviewed papers. Was involved in initiating new research fields like the Coulomb Explosion Imaging, scattering atoms and molecules from surfaces covered with self-assembled organic monolayers, and recently the Chiral Induced Spin Selectivity (CISS) effect. Co-inventor of several technologies, the Microsphere based electrons amplifier (produced by El-Mul Ltd.), the Molecular Controlled Semiconductor Resistor (in collaboration with Given-Imaging) etc. New method for enantioseparation (Kiralis). In SciCar he takes the responsibility of organizing staff visits to science laboratories and job shadow. He will help to overcome contradiction between science and social science research in education.

Research in Science impacting on Science Education

Typically, when one relates to Science, one assume that it is "all intellect" and rational. Like being an educator, to be a scientist actually requires, of course, the intellectual part, but above all, it requires passion. In fact, in my opinion, Science requires three main abilities – first, and above all, one does need to have Curiosity. To ask "How and Why". Additionally, one needs 'grit' to perform the hard work and to be persistent all the way until you find the answer. Finally, it is, of course, important to have the knowledge of the facts and methods to be able to perform the study that leads you to the answer.

Traditionally, Science education puts the emphasis on the third component. By describing, in short, my research on a new phenomenon called the 'Chiral Induced Spin Selectivity', I strive to demonstrate the importance of all three components both in science education and in scientific research.

Weizmann Institute of Science, Israel

Dr. Rachel Mamlok-Naaman is the head of the National Center of Chemistry Teachers at the Weizmann Institute of Science, and a previous coordinator of the chemistry group at the Department of Science Teaching (until June 2016). In addition, she serves as: The chair of DivCED EuChemS, IUPAC Titular member of the committee on chemical education, and executive member of the IUPAC gender gap committee. Her publications focus on the topics which are related to students' learning (cognitive and affective aspects of learning), and on teachers' professional development. She received several awards: Two from the Weizmann Institute - 1990-*Bar-Ner* (for teaching, and 2006-*Maxine Singer* for professional development of science teachers), and: (1) *ACS award (*2018*) for incorporation of sustainability into the chemistry curriculum*, and (2) *IUPAC award for* 2020 *distinguished women in chemistry and chemistry engineering*.

What does Research in Science Education say about students learning?

Different ideologies and different research agenda led to the development of research tools that try to assess science students' learning. The challenges and big questions which literature research explores, and which will be included in this presentation refer to students, to the curriculum according which they are taught, and to the science teachers. Research about students' learning will consist of examples such as (1) cognitive and affective skills, (2) motivation vs. learning difficulties, and (3) misconceptions and alternative conceptions. It is connected to the curriculum as well, by asking questions such as: Is it relevant to students' lives? Is it up-dated according

to scientific and technological discoveries? Society is constantly changing, scientific knowledge is accumulating owing to new discoveries and innovations, and information and communication technologies (ICT) became an intrinsic part of our lives. The challenges for teaching and learning science increase, and teachers should receive sustained support in order to gain knowledge of different teaching strategies and of assessment skills. This can be done by attending professional development workshops that deal with those topics, which will consequently stimulate their creativity and diversify their instructional strategies in the classroom. Such skills should improve their ability to teach and understand their students learning difficulties, since they will better understand the goals, strategies, and rationale of the curriculum. In the presentation, there will also be an example of how the active learning for which we strive in order to stimulate and motivate students towards developing of scientific literacy, also stimulates and motivates the teachers.

Tartu University

Miina Härma Gymnasium

Helen Semilarski is a practicing biology and geography teacher at Tartu Miina Harma Gymnasium. Besides teaching she is undertaking doctoral studies in educational sciences in the Science Education Centre, Institute of Earth and Life Sciences within the University of Tartu. Her research study covers meaningful learning and relevance of science teaching in competence driven settings, especially the importance of promoting core ideas and 21st century skills among learners. She is a member of International organisations such as ESERA and NARST and has presented papers in several conferences. She has published 7 internationally peer-reviewed articles, the most recent being “Exploring the complexity of student-created mind maps based on science-related disciplinary and interdisciplinary core ideas”.

How does Research in Science Education support the Practicing Science Teacher

Interdisciplinary science learning can play a central role in promoting students’ 21st century skills. However, students tend to have low perceived self-efficacy towards 21st century skills, limiting application of their actual science competence. Based on a 1.5-year intervention research study, which sought to promote students’ conceptualisation of ‘core ideas’ in science and raise science career awareness, implications are discussed on its effectiveness for everyday school science teaching and the manner in which it can promoted. Suggestions are put forward for practicing school science teachers.

University of Tartu

Jack Holbrook is Visiting Professor at Tartu University, with considerable experience in science education worldwide. His PhD is in Chemistry, but he has a strong school science teaching background, extensive experience in pre- service teacher training; added to expertise from running in-service training workshops in a range of countrie. His research covers curriculum development in science subjects, teacher education and assessment and evaluation, as well supervising PhD students in use-inspired research, scientific literacy, inquiry learning and changing teacher beliefs. He has been working since 2001 as a curriculum and assessment consultant for the Ministry of Education in Bangladesh and from 2013 for the World Bank on a competence-based curriculum project in Kuwait.

Overview of Research-driven, Paradigm Shifts in Science Education.

Advances in the way conceptions of science education change can be viewed as research driven, evidence-based changes. Just as education became a 'for all' phenomena (a paradigm shift) following the impact of the technology driven, industrial revolution, so science education developments have followed research endeavours both in the field of science and in the technological, philosophical and digital impacted science education field. Whether this is through a STEM approach, or the perceived role played by the science teacher in student competence development for a changing society, research in science education is focussing not only on guiding the manner in which science educational refocuses for the future generation, through an awareness of future career needs, but also supporting the preparation of future teachers for society to benefit from such paradigm shifts. This presentation seeks to reflect on and highlight the science education research advances driving the perceived paradigm shifts related to the earlier presentations.

THE PROJECT "ADDRESSING ATTRACTIVENESS OF SCIENCE CAREER AWARENESS" (SciCar)

SciCar – a science education project – addresses the need to systematically raise the level of expertise among researchers and educators who are involved in science & technology (STEM) education within University of Tartu (UT) and associated institutions, currently seen as ineffective in making science teaching careers attractive and enabling teaching to adopt more relevant context-based approaches. The project especially addresses, via a Twinning partnership, bringing in the expertise from top-level science education countries – Israel and Finland, particularly focusing on enhancing career awareness, enabling a capable workforce, and on promoting science-related careers. The major outcome is envisaged as a centre of excellence at UT in science education, interacting with all STEM teacher education bodies and the science education community e.g. science centres, science teacher associations. A major focus is put on (1) reducing the gap between scientist and science educator beliefs in the training emphasis of future STEM-related teachers, (2) the involvement of the science education community in making the teaching profession more attractive, (3) determining key ways & appropriate models for instituting a paradigm change with a view to increase the number of STEM-related teachers, (4) and giving emphasis to competence development in promoting science-related career awareness. The created centre is to become a platform ensuring that science researchers are guided to embrace science education expertise, making the preparation for science-related teaching careers more attractive.

Twinning partners are Weizmann Institute of Science (Israel) and University of Helsinki (Finland).

THE CONFERENCE VENUE

The residence of the Estonian Academy of Sciences, on the slope of Toompea, is the former city residence of the prominent Ungern-Sternberg noble family and a conspicuous building in Tallinn architecture. The palace on Toompea was commissioned by Count Ewald Alexander Andreas von Ungern-Sternberg, descendent of a highly influential Baltic-German noble family. The architect of the building is the renowned Berlin architect Martin Philipp Gropius.

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