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ANNOUNCEMENT

The concept and impact of the Horizon 2020 twinning project addressing the attractiveness of science awareness (SciCar), 2020–2024

Europe seeks to build a smart, sustainable and inclusive economy. Although good education and training help promote economic growth and sustainable development fuelled by research, innovation and competitiveness, knowledge-based societies also require people with higher and relevant skills, and the demand for science-related skills remains. Europe needs a future generation of researchers and practitioners who can identify and resolve major challenges, such as those related to energy, water, climate change, food, health and transport issues.

Educational sectors, particularly in the science education field, have a prominent role to play in supporting the EU ambition of resolving these challenges. Science education can contribute to the need for global competence, the capacity to analyse global and intercultural issues critically and to understand from multiple perspectives how differences affect perceptions, judgements and ideas of self and others. The European Commission has highlighted the challenge of diversity in the field of science education by indicating the following: 'Education policies and systems should address socio-economic, gender and cultural inequalities in order to widen access and provide everyone with the opportunities to pursue excellence in learning and learning outcomes' (European Commission 2015).

Of concern is the fact that, in an increasingly scientific and technological world, the science workforce, especially in Europe, is decreasing. Frequently, science curricula are not organised systematically across multiple years of school, and, emphasising discrete facts, they do not provide students with engaging opportunities to experience how science is actually practised. As a result, one of the problems in today's education is that students gain fragmental knowledge about different topics but fail to acquire a clear picture about how topics learned are interrelated (Harlen et al. 2015). Too little attention is paid to how students' comprehension of the knowledge being promoted can build from grade to grade.

Concept of SciCar

Students need to acquire knowledge about career opportunities to be able to make informed choices, but, unfortunately, middle grade students are not often made aware of career options, and few indicate knowing professionals actively working in science, technology, engineering and in environmental and mathematical fields (Maltese and Tai 2011). Furthermore, in recruiting graduates, employers state that the most important skills are teamwork, sector-specific and communication skills. Education systems worldwide strive to prepare citizens possessing a range of competences (knowledge, skills, attitudes and values) seen as essential for a capable workforce (European Commission 2015). However, concerns within STEM (science, technology, engineering and mathematics) education not only relate to a lack of sufficient workforce in the STEM field but to an insufficient number of students seeking to take up STEM careers (European Commission 2004, 2015). Although specific indicators are lacking (Archer et al. 2014; Blotnicky et al. 2018), research on STEM career motivation indicates that students' impressions of STEM education have a major impact on career decisions. Understanding how students become aware of STEM career options, how educators can help students translate awareness into pursuits of STEM careers and how to provide students with the support and skills they need to succeed are seen as crucial elements in ensuring a future STEM workforce (OECD 2018).

In many countries, including Estonia, the lack of attention to STEM education, especially in preparing chemistry and physics teachers, is a concern. One of the issues relates to teachers' ageing, with a lack of a new cohort of incoming science teachers to sustain the teaching force. Universities have recognised that the number of students undertaking STEM-related teacher courses is declining as the STEM teacher profession is not being made popular among graduates (EKKA 2019). Added to this is the need to increase the public and professional awareness about skills required for science-related careers, the need to modify STEM curricula and, hence, the need to focus on a change of paradigm in science teacher education.

According to Jang (2016), STEM workplaces in the USA require higher-order thinking skills, such as complex problem-solving skills as well as judgement and decision-making abilities. In fact, Binkley et al. (2012) and Salonen et al. (2017) associate work and life skills (WLS) with the following competences:

- 'tools for working' (information literacy, information and communication technology),
- 'ways of working' (involving communication, collaboration and teamwork),
- 'ways of thinking' (focusing on creativity and innovation, critical thinking, problem solving, decision making and metacognition) and
- 'living in the world' (requiring skills associated with citizenship, life and career, as well as personal and social responsibility).

Clearly, the acquisition of such skills can help prepare students for the transition into adult life, but they also reflect the evolving nature of future STEM challenges and their social impact. However, how students themselves evaluate and value WLS is poorly studied, even though all such skills can be meaningfully promoted through science education.

Teaching and learning in the STEM disciplines, struggling to cope with an ever-increasing science and technology knowledge base, is seen as a need to focus on promoting the core ideas within a theory-driven structure, while paying attention to meaningful learning by interrelating topics and forming connections between extensive yet isolated contextual knowledge (Harlen et al. 2015). Current research supports the necessity to pay attention to core ideas in STEM learning, especially in connection with WLS. Krajcik and Delen (2017) provide examples not only of core ideas within a science discipline, such as DNA in biology or global warming in geography, but they extend these to encompass cross-cutting concepts (or interdisciplinary ideas), which are transferrable across subjects, e.g. modelling, or attributes, e.g. collaboration. Interdisciplinary ideas are seen as invaluable as thinking tools and in explaining and predicting phenomena.

Emphasising the continuous development of core ideas can develop well-structured progression areas for learning across school years (e.g. primary to secondary) (NGSS 2013). However, research evidence is sparse on the use of core ideas by teachers, especially related to progression from compulsory to upper secondary education. Promoting STEM core ideas can be expected to lead to gaining capabilities for using learning in new situations, thus enabling problem solving at personal, social and global levels (Griffin et al. 2012) and making justified socio-scientific, evidence-based decisions.

Research in education has confirmed that single discipline teachers often lack the skill to approach interdisciplinary core ideas. To appreciate the need for aspects of interdisciplinarity, greater attention should be paid to this in teacher education curricula. Furthermore, a paradigm shift is required towards a vision of science that focuses on a wider, life-related learning, referred to as 'science education' (Holbrook et al. 2008) within the school teaching context.

In general, students do not see school science as useful for their lives and for future career developments (European Commission 2004, 2015; Tytler 2007). Furthermore, a number of studies have highlighted factors influencing the decline of interest in STEM-related subjects in transition from the end of primary to the beginning of secondary school (Anderhag et al. 2016; Tröbst et al. 2016; Walper et al. 2016). These findings suggest that promoting the relevance of science teaching during the period of adolescence becomes essential in sustaining students' interests and maintaining a strong motivation to learn. It is also essential for this need to be appreciated by STEM teachers (Mets and Viia 2018).

As perceptions of school science influence career choices, it is not surprising that the literature recognises the importance of ensuring the relevance of school science in raising positive perceptions of STEM learning in students (Stuckey et al. 2013). When school science is perceived as irrelevant, it decreases students' interest to choose STEM careers. Potvin and Hasni (2014) indicate that, unfortunately, students' interest in STEM studies has declined, leading to a lack of attractiveness of STEM professional occupations, which they perceived as being linked, at least in part, to the use of 'old-fashioned', stereotyped images of scientists. An additional factor, regrettably, is that students are not made aware of career options (Maltese and Tai 2011).

A major objective of the European SciCar twinning project is to address the attractiveness of science career awareness among science educators by systematically

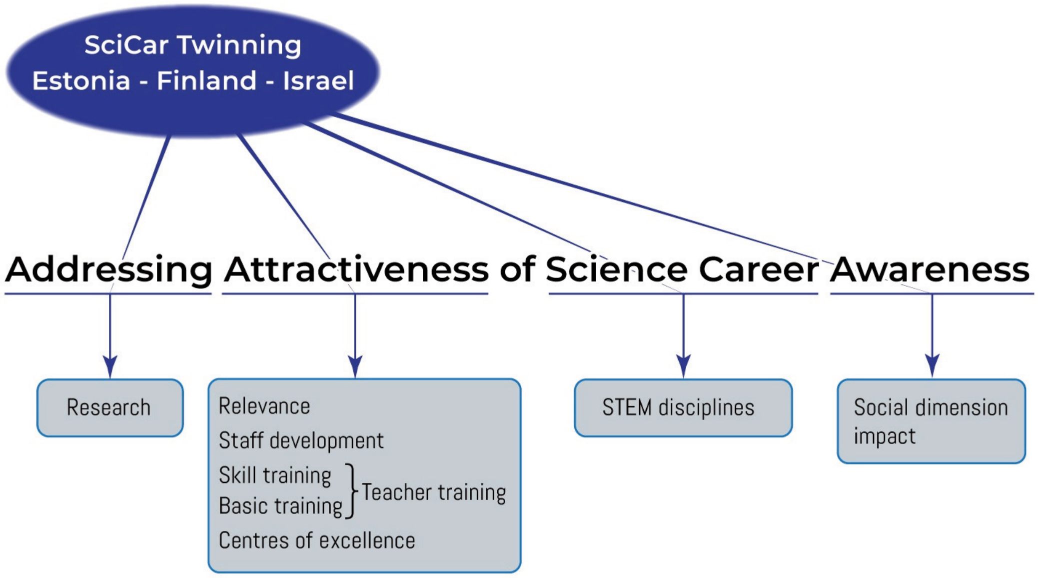

Fig. 1. The concept of SciCar.

raising the level of expertise among researchers and educators who are involved in promoting science and technology (S&T) education, related to one or more of the disciplines associated with STEM within the University of Tartu (UT) and associated institutions.

By extension, a further SciCar objective is to address a major concern regarding the academic training of science education researchers who are currently recognised as lacking sufficient skills to combine expertise in educational research, make science teaching careers attractive, and promote science-related careers by encouraging attractive science teaching in schools. Furthermore, SciCar seeks to address the academic training offered to prospective teachers in science-related fields by emphasising context-based approaches over purely content-based ones, incorporating aspects of responsible research and innovation (RRI) and integrating digital learning and assessment, particularly with respect to career awareness.

With the objective of enhancing science career awareness and the transfer of knowledge, an additional SciCar objective is to strengthen intra-institutional and inter-institutional synergies of units responsible for S&T education at the UT and its Estonian outreach institutions, by cooperating with two internationally leading counterparts in their specific fields. This cooperation is attained by promoting international integration via collaboration, based on a dynamic and sustainable framework in the field of science education between two European organisations – the University of Helsinki (UH) in Finland and the renowned science and science education research organisation in Israel, the Weizmann Institute of Science (WEIZ) (Fig.1).

Major activities impacting the SciCar outcomes

In collaboration with the Estonian Academy of Sciences, three international expert seminars were held, addressed to the Estonian academic community, i.e. science education researchers, PhD students, science teachers and science teaching staff in Estonian universities, as well as science education policymakers and funding bodies. Listed below are the summaries of the recorded seminar presentations, available on the YouTube playlist, as well as in the printed books of abstracts.

1. 'Impact of research in science education. Addressing the need for a knowledge-based society'

The seminar relates to research endeavours in the field of science education, bringing together eminent science education researchers from around the world to highlight different directions and discuss how best to overcome the gaps between students' needs and science teaching approaches. The seminar focuses on connecting the education of science teachers with changing societal expectations, the science research community and advancements in science education research. The seminar particularly addresses science education research and policymakers and seeks to promote ways in which different parties can work together to support advancement from a science education perspective to a future knowledge-based society.

2. 'Evidence of the impact of science education in attracting young people towards science studies and science-related careers'

As Europe seeks to build a smart, sustainable and inclusive economy, education and training are important factors in promoting economic growth and sustainable development by fostering innovation, productivity and competitiveness. Yet, in the increasingly scientific and technological world, the science workforce in Europe is decreasing. It is perceived that, frequently, school science curricula are not organised systematically across multiple years of schooling, and they emphasise discrete facts rather than provide students with engaging opportunities to experience how science is actually practised. The intended ways forward assume that research excellence can be achieved and maintained only if research is closely integrated with educational needs.

3. 'Expanding the focus of research in science education: new trends and best practices'

Embracing new trends and best practices in science education research is a pathway not only to advancements in the quality of education through enhanced teacher education programmes but to better prepared students for a scientifically literate and innovative society, able to adapt to changing societal and career challenges, meaningful use of technological and digital literacy and greater career awareness.

By committing to research-based approaches in preparing and empowering new generations of capable, competent educators, the current expert seminar pays attention to the importance of alignment of educational choices and science careers, building science knowledge over time and sharing best practices from Finland, Israel and Estonia, gained through the life of the Horizon 2020 project – SciCar.

Besides SciCar partners, these international expert seminars involved eminent scholars, including Prof. Joseph Krjacik, Prof. Barbara Schneider and Prof. Do-Yong Park from the USA, as well as Prof. András Patkós from Hungary.

SciCar has also targeted young researchers and doctoral students in Finland and Estonia, empowered through 'international school' meetings. Altogether, four interactive 'international schools' have taken place. During the life of SciCar, four doctoral theses have been defended under its support, and five doctoral projects have been operating under collaborative supervision with professors from the UH and WEIZ. SciCar has introduced the concept of 'job shadowing' and defined its difference from 'site visits'.

The SciCar project has sought to have an impact in four major areas:

1. Decreasing the gap between research and education, allowing better synergies at the UT institute level and internationally.
2. Enriching STEM education staff with knowledge and competences, involving staff exchanges and expert/researcher visits to promote knowledge transfer; establishing a UT 'job shadow' programme; running in-service/teacher training courses by partners within the UT.
3. Initiating joint research projects and activities, including publications between the UT, WEIZ, and UH, to raise their capacity in science education research through research seminars, a final conference, a guideline/book of guidelines, conference attendances and international (joint) publications.
4. Devising transdisciplinary (online) courses and doctoral schools between the twinning partners, along with open mobility opportunities for MA students at a 'job shadow' level.

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Photo: private collection

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REFERENCES

Anderhag, P., Wickman, P.-O., Bergqvist, K., Jakobson, B., Hamza, K. M. and Säljö, R. 2016. Why do secondary school students lose their interest in science? Or does it never emerge? A possible and overlooked explanation. *Sci. Educ.*, **100**(5), 791–813.

Archer, L., DeWitt, J. and Dillon, J. 2014. 'It didn't really change my opinion': exploring what works, what doesn't and why in school science, technology, engineering and mathematics careers intervention. *Res. Sci. Technol. Educ.*, **32**(1), 35–55.

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M. et al. 2012. Defining twenty-first century skills. In *Assessment and Teaching of 21st Century Skills* (Griffin, P., McGaw, B. and Care, E., eds). Springer, Dordrecht, 17–66.

Blotnicky, K. A., Franz-Odentaal, T., French, F. and Joy, P. 2018. A study of the correlation between STEM career knowledge, mathematics self-efficacy, career interests, and career activities on the likelyhood of pursuing a STEM career among middle school students. *Int. J. STEM Educ.*, **5**, 22.

EKKA (Estonian Quality Agency for Higher and Vocational Education). 2019. *Assessment report of educational sciences.* Tallinn, Estonia.

European Commission. 2004. *Increasing Human Resources for Science and Technology in Europe*. Report presented at the conference *Europe Needs More Scientists*, Brussels, 2 April 2004.

European Commission. 2015. *Does the EU Need More STEM-Graduates? Final Report.* Publications Office of the European Union, Luxembourg. https://data.europa.eu/doi/10.2766/000444 (accessed 2021-12-07).

Griffin, P., Care, E. and McGaw, B. 2012. The changing role of education and schools. In *Assessment and Teaching of 21st Century Skills* (Griffin, P., McGaw, B. and Care, E., eds). Springer, Dordrecht, 1–15.

Harlen, W. (ed.). 2015. *Working with Big Ideas of Science Education*. Science Education Programme (SEP) of IAP, Trieste, Italy.

Holbrook, J., Rannikmäe, M., Reiska, P. and Isley, P. (eds). 2008. *The Need for a Paradigm Shift in Science Education for Post-Soviet Societies*. Peter Lang GmbH, Germany.

Jang, H. 2016. Identifying 21st century STEM competencies using workplace data. *J. Sci. Educ. Technol.*, **25**, 284–301.

Krajcik, J. and Delen, I. 2017. Engaging learners in STEM education. *Estonian J. Educ.*, **5**(1), 35–58. https://doi.org/10.12697/eha.2017.5.1.02b

Maltese, A. V. and Tai, R. H. 2011. Pipeline persistence: examining the association of educational experiences with earned degrees in STEM among U.S. students. *Sci. Educ.*, **95**(5), 877–907.

Mets, U. and Viia, A. 2018. *Tulevikuvaade tööjõu- ja oskuste vajadusele: haridus ja teadus (A forward-looking view of labour and skills needs: education and research).* Brief research report. SA Kutsekoda, Tallinn.

National Research Council. 2013. *Next Generation Science Standards: For States, By States*. The National Academies Press, Washington, DC. https://doi.org/10.17226/18290

OECD. 2018. *Future of Education and Skills 2030*. https://www.oecd.org/en/about/projects/future-of-education-and-skills-2030.html (accessed 2021-12-07).

Potvin, P. and Hasni, A. 2014. Interest, motivation and attitude towards science and technology at K-12 level: a systematic review of 12 years of educational research. *Stud. Sci. Educ.*, **50**(1), 85–129.

Salonen, A., Hartikainen-Ahia, A., Hense, J., Scheersoi, A. and Keinonen, T. 2017. Secondary school students' perceptions of working life skills in science-related careers. *Int. J. Sci. Educ.*, **39**(10), 1339–1352.

Stuckey, M., Hofstein, A., Mamlok-Naaman, R. and Eilks, I. 2013. The meaning of 'relevance' in science education and its implications for the science curriculum. *Stud. Sci. Educ.*, **49**(1), 1–34.

Tröbst, S., Kleickmann, T., Lange-Schubert, K., Rothkopf, A. and Möller, K. 2016. Instruction and students' declining interest in science: an analysis of German fourth- and sixth-grade classrooms. *Am. Educ. Res. J.*, **53**(1), 162–193.

Tytler, R. 2007. Re-imagining Science Education: Engaging Students in Science for Australia's Future. *Australian Education Review*, **51**. ACER, Melbourne, Victoria.

Walper, L. M., Pollmeier, K., Lange, K., Kleickmann, T. and Möller, K. 2016. From general science teaching to discipline-specific science teaching: physics instruction and students' subject-related interest levels during the transition from primary to secondary school. In *Insights from Research in Science Teaching and Learning: Selected Papers from the ESERA 2013 Conference* (Papadouris, N., Hadjigeorgiou, A. and Constantinou, C., eds). Springer, Switzerland, **2**, 271–288.