FACTORS EXPLAINING GYMNASIUM STUDENTS' TECHNOLOGY RELATED CAREER ORIENTATIONS

Abstract. *In the current study, gymnasium students' technology-related career orientations were studied from a Social Cognitive Career Theory perspective. In order to address students' lack of interest in technology related careers as recognised worldwide, the design-based science learning (DBSL) approach was used. For the purposes of the current study, five learning modules were adapted by the research team from those developed within a European project and taught by science teachers (N=18). At the beginning of the study, 10th-11th grade students (N=314) completed a questionnaire consisting of measures of career goals, interests, self-efficacy, outcome expectations and contextual supports in relation to technology. After teaching 2-3 modules, students' technology-related career goals were again determined using a reduced version of the same questionnaire. Based on the outcomes, it was found that at the beginning of the study, boys' future career goals were significantly more connected with technology than those for girls. In addition, boys had a stronger background related to technology. As a result of the intervention, students' technology-related career goals became significantly stronger for both boys, as well as for girls, but the change was more pronounced for girls.*
Key words: *design-based science learning, gymnasium students, Social Cognitive Career Theory, technology-related career interests.*

Toomas Vaino,
Katrin Vaino,
Miia Rannikmäe,
Jack Holbrook

Introduction

The importance of technological development for economical sustainability and success is self-evident. This in turn, puts growing demands for a suitably educated workforce. On the other hand, students' knowledge, skills and attitudes related to science, technology, engineering and mathematics (STEM) may limit, or expand the range of students' future career options. In many countries, therefore, technology and engineering aspects and their interplay with science and mathematics are strengthened within general education (e.g. Ministry of Education, 2007; National Science Learning Centre, 2008; Next Generation Science Standards, 2012). At the same time, as indicated by different international reports (High Level Group on Science Education, 2007; Henno, 2010; Business Europe, 2011), there is a serious decrease in young people's interest in STEM-related studies and careers.

While girls are as capable as boys in the science disciplines at the general school level (VanLeuvan, 2004; OECD, 2010), women constitute only a small percentage of the workforce within the field of science and technology (VanLeuvan, 2004; Lent, Brown, Sheu, Schmidt, Brenner, Gloster, Wilkins, Schmidt, Lyons, & Treistman, 2005; National Science Foundation, 2011). Girls especially seem to suffer more than boys from stereotypes that are related to external (parents, teachers, society) expectations (OECD, 2008). However, it should be noted that some specific fields, such as medical sciences, show a different picture, where women are over-represented (National Science Foundation, 2011).

Students low interest in science and technology careers may be also related to their low awareness of a range of career opportunities which can be counteracted by studying science and technology, and also their lack of familiarity with the expectations of science and technology careers (OECD, 2006; Eccles, 2007; Lavonen, Gedrovics, Byman, Meisalo, Juuti, & Uitto, 2008; Vaino, Vaino, & Rannikmäe, 2015). As pointed out by Cole (2011), students may be well acquainted with professionals they meet in their every-day

Toomas Vaino
University of Tartu, Tartu, Estonia
Katrin Vaino
University of Umeå, Sweden
Miia Rannikmäe, Jack Holbrook
University of Tartu, Tartu, Estonia

life, such as teachers, medical workers, officers, etc. but most have rarely been exposed to (other) STEM careers or have a role model in these fields, only if their parents or relatives work in STEM fields. It is surely sad if we lose students who are actually well suited for STEM careers, only because they are not familiar with the variety of career opportunities in these fields.

As suggested by Michigan Department of Education (2015), students need comprehensive and up-to-date information about different careers, including educational requirements, descriptions of typical work tasks, working conditions, incomes, and opportunities for advancement. Moreover, career awareness activities need to provide students with a better understanding of the changing nature of the labour market, mainly, due to technological development but also because of the impact of a global economy (Michigan Department of Education, 2015). In that direction, Cole (2011) suggests a number of practical solutions such as traditional face-to-face as well as on-line conversations with professionals, interactive video conferences, use of virtual career counsellors, virtual job shadowing and the use of relevant video excerpts. For example, in the study carried out by Wyss (2013), students' awareness of possible STEM careers is raised through the use of video interviews with STEM professionals. Asch-bacher, Li and Roth (2010) underscore not only the role of schools, but the role of different communities of practice to play in career and identity development of young people and suggest a need for interventions to help socializers better understand the nature of STEM careers and the ways how students can be informed and encouraged.

STEM Careers

It is quite common to consider STEM as a general and intertwined construct. At the same time, STEM fields can involve a wide range of disciplines. Although there exists some disagreement with whether social sciences should be also included within STEM, it is still more common to see STEM as consisting of natural and physical sciences, technology and engineering (including also computer/information technologies), and mathematics (Chen & Weko, 2009). The following tries to define "science", "technology" and "engineering" within STEM in order to cast some light to the possible careers within each and across these fields.

Although different definitions are given to the term "science", there is much in common. For example, the Academic Press Dictionary of Science and Technology (Morris, 1992) defines science as

> the systematic observation of natural events and conditions in order to discover facts about them and to formulate laws and principles based on these facts; the organized body of knowledge that is derived from such observations and that can be verified or tested by further investigation; any specific branch of this general body of knowledge, such as biology, physics, geology, or astronomy (p. 1926).

Thus, science careers are, by and large, related to what scientists (physicists, biologists, biochemists, neuro-scientists, etc.) within the natural and physical sciences do. Unfortunately, when referring to "technology", it must be noted that this term tend to be more vague and ambiguous. Some frameworks, but also the public generally tend to see "technology" only as a product (tools, artefacts, machines, equiptment, systems, techniques), or an application of scientific knowledge (Ihde, 1991; DiGironimo, 2011). At the same time, Gardner (1999) puts forward a more broad definition of "technology" - it can refer to artefacts (products), processes through which artefacts, applications and solutions are made, but also to entire social systems and fields of work or study. The last is more suitable when technology as a professional field is an object of discussion. Although closely interrelated and having much in common, e.g. both science and technology are social enterprises, include a lot of experimentation and are loaded with values and political influences (Ihde, 1991), the boundary line between science and technology seems to lay in the purpose – when the purpose of science is to improve our understanding about the world and develop theories about the phenomena, then the purpose of technology is to satisfy human needs while solving practical problems in order to raise our quality of life (Gardner, 1999). Still, if the field "applied sciences" is the focus, this boundary line becomes quite blurred. However, the Feibleman's (1961) definition of "applied sciences" as the "use of pure science for some practical human purpose" places it rather closer to "technology" than "science". Feibleman (1961) also gives an example that helps better to understand the brittle distinction between science and applied sciences:

> The theoretical biochemist is a pure scientist working for the most part with carbon compounds. The biochemist is an applied scientist when he explores the physiological effects of some new drug, perhaps

trying it out to begin with on laboratory animals, then perhaps on himself or on volunteers from his laboratory or from the charity ward of some hospital. (p. 310)

And extending further the same example – when this drug is going to become an industrial product, it becomes already a matter of "technology". There is a number of engineers and technologists who will design the product, design and optimise relevant industrial processes, logistics, deal with safety, etc. As both professions (or the groups of professions), are taken together, it becomes clear that it is not an easy task to distinguish "engineering" from "technology". This is especially so when different philosophers of technology (e.g. Ihde, 1991; Mitcham, 1994) have used both of these terms interchangeably. Based on the American Heritage Dictionary of the English Language (2011), the term "engineering" has been demarcated as

the application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems; the profession of or the work performed by an engineer.

Based on this definition, "engineering" refers to the processes such as designing and inventing in order to arrive at products, tools, machines, or systems, while "technology" is seen as a more overarching construct (Gardner, 1999). This suggests that engineers and designers are working within the broader field called "technology" together with technologists, technicians, etc. – careers that are considered common careers within "technology". According to the International Technology Education Association (2007), the field of "technology" can be further divided into sub-fields such as medical technologies, agriculture and related biotechnologies, information and communication technologies, transportation technologies, manufacturing technologies and construction technologies.

As in the study conducted by the authors (reported elsewhere), in which gymnasium students did not distinguish "engineering" from the field of "technology", it was decided to use Gardner's (1999) broader definition when developing specifications about the term "technology" (engineering was seen as part of technology) which was further given for students in the student questionnaire.

STEM Education

The term "STEM education" refers to teaching and learning in the fields of science, technology, engineering, and mathematics (Gonzalez & Kuenzi, 2012), thus all science, mathematics, and technology teachers ought to be considered as STEM teachers. Still, as Sanders (2009) suggests, in many cases, "STEM education" simply refers to the four separate and distinct fields without substantial interactions among the stakeholders. Therefore, in place of STEM education as a quite worn-out catch phrase, Sanders and Wells (2006, quoted in Sanders, 2012) suggest to use the term "integrative STEM education" which refers to

technological/engineering design-based learning approaches that intentionally integrate the concepts and practices of science and/or mathematics education with the concepts practices of technology and engineering education. Integrative STEM education may be enhanced through further integration with other school subjects, such as language arts, social studies, art, etc. (p. 103).

Vasquez, Sneider & Comer (2013) have further underscored the notion that STEM education should be seen as an approach that removes the traditional barriers separating the four disciplines and integrates them into real world providing students with relevant learning experiences.

Notwithstanding the complexity and ambiguity of the term, different reports, suggestions and national strategies for improving STEM education have been released during the last decade in many countries, e.g. in US, Australia, Scotland (NGA, 2007; Science and Engineering Education Advisory Group, 2012; Marginson, Tytler, Freeman, & Roberts, 2013). These, but also other documents (e.g. NRC, 2011), have addressed the concern about the shortage of suitably prepared teachers able to meet the challenges of STEM teaching. Such teaching basically means that teachers should be ready to conduct integrated courses, implement project-, problem- or design-based approaches or tackle STEM-related global issues, which include teaching and learning in their classrooms, two or more of the STEM subject areas and even beyond. Many teachers at schools previously prepared to teach single or two isolated subjects within STEM are not actually prepared to become "STEM teachers" in its full and integrated

meaning. Prior and obviously inadequate teacher education increases therefore the need for specially geared continuous professional development programmes. Fortunately, there is still a gradually growing body of research evidence showing that strong professional learning communities may help teachers to facilitate different STEM-focused approaches when they are provided with relevant support (based on the literature review conducted by Fulton, Doerr, & Britton, 2010). Sanders (2009) has also found that several semesters working together with STEM teachers from different disciplines and using course assignments that required cross-discipline collaboration, is a successful means of facilitating new integrative approaches, and helping to develop understanding of other STEM education cultures. In order to provide science teachers with additional knowledge in technology and engineering, a set of lectures and workshops have been carried out within the approach described above by Sanders (2009). Quigly and Herro (2015) demonstrate how their transdisciplinary scenario- and project-based approach, together with close collaboration between the project participants (also enabled by technology), help to familiarise teachers with the new approach and understand the principles of the STEAM (added A= art). The other projects and programmes (still, not always focused on integrated STEM approaches) that have been found to be effective for supporting teachers' professional development, have shared the following features:

1) they provide a sustained, content-focused approach, frequent collaboration and in-depth teacher involvement;
2) address teachers' classroom work and the problems they encounter in school settings;
   allow teachers to try out and inquire new strategies in their classrooms, reflect on and discuss their experiences in a trusting environment;
3) there exists coherence between the programme and teachers' personal goals and needs (Birman, Desimone, Garet, & Porter, 2000; Education Development Center, Inc., 2008; Wei, Darling-Hammond, Andree, Richardson, & Orphanos, 2009; Vaino, 2013).

Determinants of Students' Interest towards STEM Careers

The aspects that may influence or predict students' interest towards science as well as mathematics-related careers, have been exhaustively studied over many years. These aspects have been:

- students' interest toward science subjects (e.g. Osborne, Simon, & Collins, 2003; Simon & Osborne, 2010);
- students' individual interests and self-concept (e.g. Krapp & Prenzel, 2011; Taskinen, Schütte, & Prenzel, 2013);
- social supports and barriers, including gender aspects (e.g. Lent, Brown, Brenner, Batra Chopra, Davis, Talleyrand, & Suthakaran, 2001; Fouad, Hackett, Smith, Kantamneni, Fitzpatrick, Haag, & Spencer, 2010).

Several authors have also studied students' career orientations towards STEM generally and have found many significant determinants, mostly related to gender, teachers and teaching quality, peers, family members (Aschbacher, Li, & Roth, 2010; Cerinsek, Hribar, Glodez, & Dolinsek, 2013), prior knowledge, interest and engagement in school science (Woolnough, Guo, Salete Leite, de Almeida, Ryu, Wang, & Young, 1997; Nugent, Barker, Welch, Grandgenett, Wu, & Nelson, 2015). Based on these studies, it can be hypothesised that students' relatively poor interests in STEM studies and careers (OECD, 2006) can be explained by one or the combination of the following factors: low-quality teaching and disinterested science and mathematics teachers, discouraging peers and teachers, lack of family support, poor science knowledge and lack of interest towards school science and science more generally. Furthermore, STEM studies and related careers are perceived often as too difficult and requiring more effort than students are willing to exert (Aschbacher, Li, & Roth, 2010). Social norms that see STEM careers as non-traditional for women seems to play an additional discouraging role for girls (Fouad, Hackett, Smith, Kantamneni, Fitzpatrick, Haag, & Spencer, 2010). However, family models working within STEM fields seems to strengthen girls' confidence to undertake science and technology studies (OECD, 2006). The last is of course, valid for both genders (Bame, Dugger, de Vries, & McBee, 1993). Gender role socialization seems to lead to gender differences in terms of work one likes to do in the future: females tend to want to work at occupations where they can help and/or interact with other people (Teppo, & Rannikmäe, 2008; Sjøberg & Schreiner, 2010), that enable contributing to sustainable development and protecting the environment (Cerinsek, Hribar, Glodez, & Dolinsek, 2013), while males tend to want to work at occupations that provide opportunities to become famous (Sjøberg & Schreiner, 2010), manipulate physical objects and abstract concepts (Eccles, 2007), earn lots of money, control other people and invent new things (Sjøberg & Schreiner, 2010). The questions are also posed how to re-engineer the education in

order to offer equal opportunities to both boys and girls, but no consensus has yet been reached concerning the assumptions, methods, or results that can be achieved (OECD, 2008).

The aspects of students' technology and engineering related career orientations particularly and separately from the other STEM careers have received relatively little attention in the literature. The exceptions here have been those conducted with college and university students (e.g. Lent, Brown, Sheu, Schmidt, Brenner, Gloster, Wilkins, Schmidt, Lyons, & Treistman, 2005; Alexander, Holmner, Lotriet, Matthee, Pieterse, Naidoo, Twinomurinzi, & Jordaan, 2011). In the current study therefore, emphasis was given only to gymnasium (upper secondary) students' technology-related career orientations (including engineering) and to the factors that were able to explain their orientations. The planned intervention was also geared to influence students' awareness about and values towards careers particularly in this direction.

Social Cognitive Career Theory

In order to understand factors that may explain gymnasium students' technology-related career orientations which, in turn, can help to develop relevant intervention approaches, the Social Cognitive Career Theory (SCCT) (Lent, Brown, & Hackett, 1994) was used in the current study. The SCCT, being itself a derivative of Social Cognitive Theory (Bandura, 1986), has been widely used and validated in a number of empirical studies (e.g. Lent, Brown, & Hackett, 1994; Lent, Brown, Sheu, Schmidt, Brenner, Gloster, Wilkins, Schmidt, Lyons, & Treistman, 2005; Lent, Lopez, Lopez, & Sheu, 2008). The central characteristics in SCCT are the individual's *self-efficacy*, *outcome expectations*, *personal interests* and *contextual supports/barriers* used to explain reasoning behind students' *career goals* (see Figure 1).
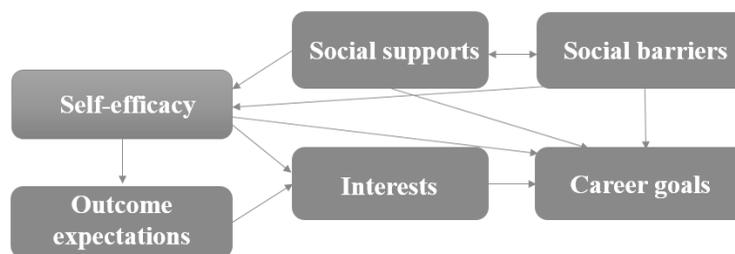
Figure 1:   Social cognitive career model (Lent, Brown, & Hackett, 1994).

According to Bandura (1986), self-efficacy is defined as the perception of one's abilities (e.g. knowledge, skills) to perform a task within a certain domain, whereas outcome expectations are the anticipated consequences of a course of action, e.g. perceived monetary, self-satisfaction and social outcomes. Personal (individual) interest is interpreted as a relatively stable tendency to occupy oneself with an object of interest (Krapp & Prenzel, 2011), this being technology in the context of the current study. Self-efficacy and outcome expectations together have proven to predict the interests an individual develops (Lent, Brown, & Hackett, 1994). Self-efficacy is found to have an influence on outcome expectations related to a given area, but not the other way around (Lent, Brown, & Hackett, 1994). In other words, higher self-efficacy promotes more positive outcome beliefs, but high outcome expectations (e.g. expected high salary) does not make people perceive themselves more competent in a given area. In a SCCT context, a career goal is defined as the decision to choose a particular career area (Lent, Brown, & Hackett, 1994). To understand students' career goals is particularly important, as different theories (e.g. Theory of Reasoned Action, Fishbein & Ajzen, 1975; Theory of Planned Behaviour, Ajzen, 1991) together with their concurrent research have proven the relationship between personal goals (intentions) and actual choice behaviours. Self-efficacy has shown to influence career goals directly, but also through personal interests in a given area (Lent, Brown, & Hackett, 1994). Thus, based on SCCT, persons aim to enter career fields in which they believe they have the required capabilities, interest, and believe they are able to attain favourable outcomes (Lent, Brown, Sheu, Schmidt, Brenner, Gloster, Wilkins, Schmidt, Lyons, & Treistman, 2005). In addition, social supports and barriers (gender, socio-economic status, family background, provision of relevant information by school, encouragement/discouragement by teachers etc.) relate to career goals directly, as well as through self-efficacy and outcome expectations, e.g. supports and barriers

have an impact on self-efficacy and outcome expectancy, and in turn, relate to goals (Bandura, 1999; Lent, Brown, Sheu, Schmidt, Brenner, Gloster, Wilkins, Schmidt, Lyons, & Treistman, 2005). Supports and barriers are usually inversely related; that is, the perception of greater support is associated with lesser barriers (Lent, Brown, Brenner, Batra Chopra, Davis, Talleyrand, & Suthakaran, 2001).

Design-based Science Learning

In order to address students' (especially girls') poor interest in technology and technology-related careers (OECD, 2006; Business Europe, 2011), design-based science learning (DBSL) is put forward as an approach in the current study. Design-based science learning, also called design-based science or design-based learning, is an approach that combines the elements of engineering design within inquiry learning, engaging students' in scientific reasoning through solving authentic design problems (Mehalik, Doppelt, & Schunn, 2008; Vattam & Kolodner, 2008; Apedoe & Schunn, 2013; Gomez Puente, van Eijck, & Jochems, 2013).

In DBSL, a trigger for students to promote further science learning, is a design-project in which students are expected to develop a technological solution to a problem (Fortus, Dershimer, Krajcik, Marx, & Mamlok-Naaman, 2004; Apedoe & Schunn, 2013). The problem, itself, may grow out of actual needs, perceived by students themselves (Apedoe, Reynolds, Ellefson, & Schunn, 2008). Moreover, DBSL can build on students' natural everyday design experiences (Fortus, Dershimer, Krajcik, Marx, & Mamlok-Naaman, 2004). Therefore, DBSL is an excellent approach for integrating scientific principles, technology applications, engineering design, and mathematics into a single learning module or a series of modules that compile a whole course and it can be thus considered as an "integrated STEM" approach. The design process within DBSL is similar to problem-solving and has a general structure, which may include stages such as: (a) defining the problem and identifying the need; (b) collecting information; (c) introducing alternative solutions; (d) choosing the optimal solution; (e) designing and constructing a prototype, and (f) evaluation of the prototype (Doppelt, Mehalik, Schunn, Silk, & Krysinski, 2008; Laius & Rannikmäe, 2011). Still, as warned by Jonassen (2011), this process cannot be seen as simple and unidirectional as design problems are among those most ill-defined and complex.

A number of studies have shown the advantages of design-based learning as a means for increasing motivation, developing higher-order cognitive skills e.g. problem-solving and inquiry skills (Kolodner, Camp, Crismond, Fasse, Gray, Holbrook, Puntambekar, & Ryan, 2003; Kask, 2009; Silk, Schunn, & Strand Cary, 2009), fostering personal and interpersonal traits (Doppelt, 2003), enhancing achievements of both high- and low-achievers (Doppelt, Mehalik, Schunn, Silk, & Krysinski, 2008). However, there are only a few studies which relate DBSL with students' technology-related career orientations while also considering possible gender differences. Findings based on the results of the previous study using DBSL modules, conducted by Vaino, Vaino, and Rannikmäe (2015), show it is possible to broaden gymnasium students' understanding about the diverse field of technology and how science and technology are interrelated. Still, there is a need for further intervention-type studies aiming to address students' lack of technology-related career interests through raising their awareness of characteristics associated with different technology careers and opening up the full potential of this expanding employability area.

Methodology of Research

The purpose of this study was to examine gymnasium students' technology-related career orientations and identify factors that may explain their orientations. Moreover, the study included an intervention which lasted one school year. It was expected to improve students' technology related career interests first, through introducing participating science teachers with integrated STEM approaches, such as design-based science learning approach and secondly, the same approach was implemented by the teachers in their classrooms. The following research questions were posed:

1) What technology-related career orientations do students (boys and girls) hold?
2) What are the factors that explain students' technology-related career goals?
3) Is there any change in students' technology related career goals through the implementation of specially designed modules?

Sample

The participants in this study were 10th-11th grade students (16-17 years old; N=314) and 18 physics and chemistry teachers from 11 Estonian schools. The teachers were volunteers in a sense that they agreed to participate in the project through participating in in-service sessions during a school year and carry out adapted modules in their classrooms. All three male teachers were physicists and the 15 female teachers were, accordingly, 5 physics, 8 chemistry and 2 teaching both physics and chemistry. All teachers were experienced and had taught more than 5 years. The number of students formed itself based on the available students in grades 10-11 who were taught by the participant teachers.

Design and Implementation of the Modules

The five modules, developed by partner universities in the EU FP7 ESTABLISH (http://www.establish-fp7.eu/) project and adapted by the research team for the purposes of the current, design-based science learning approach, were taught within optional (8 schools) as well as compulsory chemistry (1 school) and physics (3 schools) courses.

The particular modules and the context of these modules were chosen and adapted, based on findings related to different studies on students' interests. Based on the survey of Teppo and Rannikmäe (2008), ninth grade girls were highly interested in health, appearance and other aesthetical aspects, while boys were more interested in technology generally and in electrical phenomena more particularly, while problems related to the cosmos and mysterious phenomena held high interest for both boys and girls. The international study, conducted by Elster (2006), showed that students were more interested in topics that were related to practical applications and where social aspects were involved in the science learning. Sjøberg (2002) showed that students were more interested to learn physics topics, such as sound and acoustics in the context of music, than learning these topics without a music context.

Based on the rationale provided above, four aspects were emphasised in the modules (Vaino, Vaino, & Rannikmäe, 2015):

- Design- and inquiry-based learning played an integral role in every module.
- Science content was embedded in, and related to, technological applications demonstrating its potential usability.
- Every module began from an authentic problem that had importance in society, as well as being relevant to students' lives seen as a trigger for learning science in depth (Holbrook & Rannikmäe, 2010). Students were expected to develop a solution (product, artefact) to the stated problem, e.g. they had to design a cosmetics product or suggest a design for a Martian greenhouse. During this process, students were guided to follow the design cycle suggested by Doppelt, Mehalik, Schunn, Silk, & Krysinski, 2008 (see earlier).
- Within every module, technology related careers were introduced involving different aspects: providing students with relevant knowledge about the nature of possible careers within a field and highlighting positive role models (from both sexes) through short real-life stories and video excerpts. Moreover, through web searches, students familiarised themselves with educational requirements and typical work tasks for a profession of their interest, related to the topic of a particular module. And last but not least, students themselves became "engineers" through the design process when developing a product or application.

The final list of modules selected and adapted by the research team was as follows:

- Why make home-made cosmetics?
- Medical imaging
- Sound
- Greenhouses on Mars?!
- Chitosan – the fat magnet?

potentially catering for girls' interests in health and aesthetics by modules such as „Why make home-made cosmetics?", „Medical imaging" and „Chitosan – the fat magnet?", while „Greenhouses on Mars?!" (space, extraordinary phenomena) and „Sound" (extraordinary phenomena) were expected to address equally interests of both sexes.

Teacher In-service Sessions

In order to provide participating physics and chemistry teachers (all of them prepared to teach single or two science subjects) with relevant content and pedagogical content knowledge, 5 in-service sessions (1-2 days per session) were conducted. The first session was at the end of the school year, three others throughout the next school year, and the last summary meeting before the beginning of the following school year. When designing the sessions, the authors tried to relate the current in-service programme to the research- and best practice-based guidelines, given in the literature on teacher professional development (see the earlier section: "STEM education"). Most of all, an attempt was made to provide teachers with frequent collaboration (between teachers and between teachers and the research team) and in-depth involvement throughout the extended period of time. During the first session, teachers were introduced with the main ideas of a design-based science learning approach and available learning modules which were previously adapted by the research team. After beginning to implement modules in the classroom, the teachers also became contributors helping to improve and refine the design of every module. Throughout the following sessions, teachers had also the possibility to reflect on their experience related to implementation of a particular module, demonstrate classroom artefacts and share their problems with the other participants. The content of the lectures which was geared to extending teachers' knowledge, mainly in technology, engineering, and related careers and to a lesser extent in fundamental science and pedagogical content knowledge, was negotiated with teachers. The purpose of all lectures was to build up and/or complement teachers' knowledge in ways that would afterwards enable them to teach a particular module in their classroom. For example, when teachers were working through the module "Greenhouses on Mars?!", a presenter was requested from the team consisting of engineers and scientists who were developing construction prototypes for extraordinary conditions. In every session, teachers together with the research team became "students" and worked through a module or two from the beginning to the end, including discussions in groups and the design of solutions and artefacts. During the last session, all participants presented a summary of their practice through a short PowerPoint presentation.

Instrument

In the current study, the STEM Career Interest Survey (STEM-CIS) instrument (Kier, Blanchard, Osborne, & Albert, 2013) was adapted and used as a part of larger questionnaire consisting of three sections. In the first section, background data were asked which included students' gender, date of birth (for matching pre and post test data), school, stream and their self-efficacy in learning science subjects (altogether 8 items). The second section explored students' technology related attitudes and understanding of the nature of technology (4 open-ended questions including 25 statements) and the last section was a students' technology-related career sub-scale (10 statements, all derived from STEM-CIS). The results of the second section were analysed and reported elsewhere.

The original STEM-CIS instrument consists of four subscales exploring students' career interests in (1) science, (2) technology, (3) engineering, and (4) mathematics and is designed to measure changes in student interest in STEM subjects and potential careers as a function of the intervention. These sub-scales are validated for independent, as well as for combined, use by Kier, Blanchard, Osborne, and Albert (2013). The STEM-CIS instrument is based on Social Cognitive Career Theory (Lent, Lopez, Lopez, & Sheu, 2008). In the current study, only the technology related sub-scale is used and then in an adapted version.

In the preface of the third part of the questionnaire, while completing the questionnaire students are asked to think of „technology", as a combination of technology, technological design and what engineers and technologist do. The items of the questionnaire were reviewed by a group of science teachers and educators for adequate content and pilot tested with a small sample of students (N=34) prior to data collection, so as to ensure readability and clarity. The instrument was administered at the beginning of the school year and immediately after teaching 2-3 DBSL modules (the number of modules depended on the decision of the particular teacher). For the latter, a reduced version of the questionnaire was used, as some background data and data believed by the research team to remain constant as a result of the intervention, were eliminated. In the questionnaire, students were asked to rank their degree of agreement with a given statement on a 5-point Likert scale from *strongly agree* to *strongly disagree*. The items of the third part of the questionnaire were categorised based on the Social Cognitive Career Theory (Lent, Brown, Sheu, Schmidt, Brenner, Gloster, Wilkins, Schmidt, Lyons, & Treistman, 2005), as follows:

- Personal goal (1 items)
- Self-efficacy (1 items)
- Personal interest (2 items)
- Contextual supports (4 items)
- Outcome expectations (2 items)

Data Analysis

In order to answer the first research question, descriptive statistics and an independent samples t-test were conducted. The t-test was used to find out whether there was any difference between boys' and girls' technology-related career goals and related factors.

Additionally, two general linear models, separately for boys and for girls, were developed in order to find out the strongest predictors of students' technology-related career goals.

For the third question, a paired samples t-test was conducted: students' technology-related career goals were compared before and after teaching the modules. The test was conducted separately for boys and girls. The significance level for all conducted analyses was determined, a priori, to be $p \leq 0.05$.

Results of Research

Students' mean responses to the questionnaire before teaching the designed modules are presented in Table 1. Based on the data, boys' future career goals are significantly more connected with technology than those for girls (by a mean difference of +0.90** on a 5-point scale); boys read more technology related information and deal more with technology related issues (+1.14**), have higher parental expectations related to careers in technology (+0.72**), have more role models in the technology field (+0.41*) including role models within their family (+0.70**), like more to talk with persons working in the field of technology (+0.68**) and have higher self-efficacy in activities that are related to technology (+0.41*). Boys as well as girls tend to believe that their teachers have not encouraged them enough to choose a career in the field of technology (mean values 2.65 and 2.43, respectively). Slightly more positive are their responses to *School has made me aware of the careers in the field of technology* with mean values 2.74 and 2.89, respectively. It was also found that girls have less tendency to believe that obtaining good knowledge in technology enables them to enter different careers within the field of technology (-0.41*), although the mean values for both boys' and girls' are relatively high, being respectively 4.21 and 3.80.

Table 1. **Students' ratings on the technology related career sub-scale items.**

Category	Item	Mean (SD)		Mean difference
		Boys N=149	Girls N=165	
Personal goal	I plan my future career to be in a technology related field	3.44 (0.99)	2.54 (1.00)	0.90**
Self-Efficacy	I am able to do well in activities that are related to technology	3.65 (0.82)	3.24 (0.84)	0.41*
Personal interest	I like to talk with persons who use technology in his/her career or who works in the field of technology	3.56 (0.97)	2.88 (0.90)	0.68**
	I like to read technology related information or deal with technology related issues	3.59 (0.98)	2.45 (1.01)	1.14**
Contextual support	I know of someone in my family who uses technology in his/her career, or works in the field of technology	3.58 (0.97)	2.88 (0.99)	0.70**

| Category | Item | Mean (SD) | | Mean difference |
		Boys N=149	Girls N=165	
	I have a role model in the field of technology	3.18 (1.24)	2.81 (1.37)	0.37*
	School has made me aware of the careers in the field of technology	2.74 (0.96)	2.89 (1.03)	0.15
	My teachers have encouraged me to choose a career in the field of technology	2.65 (0.87)	2.43 (0.89)	0.22
Outcome expectation	My parents would like it if I choose a technology related career	3.43 (0.98)	2.71 (1.13)	0.72**
	If I possess good knowledge in technology, I will be able to undertake many different types of careers	4.21 (0.85)	3.80 (0.86)	0.41*

* p ≤ 0.05, ** p ≤ 0.001

A General Linear Model (GLM) analysis (Graham, 2008) was conducted to discover the main predictors amongst predetermined and some added factors on students' technology-related career goals. In Table 2, the standardized beta values of two models (separately for boys' and girls') were given.

Table 2.   Outcomes from an analysis of boys' and girls' regression models.

| Category | Predictor of „I plan to work in my future career in a technology related field" | Standardized Beta | |
		Boys N=149	Girls N=165
Self-efficacy	I am able to do well in activities that are related to technology	0.381**	0.007
Personal interest	I like to talk with persons who uses technology in their career or who work in the field of technology	0.167	-0.021
	I like to read technology related information or deal with technology related issues	0.299**	0.194*
Contextual support	I know of someone in my family who uses technology in his/her career or works in the field of technology	0.062	-0.101
	I have a role model in the field of technology	0.046	0.169
	School has made me aware of the careers in the field of technology	0.051	0.022
	My teachers have encouraged me to choose a career in the field of technology	0.030	0.053
Outcome expectation	My parents would like it if I choose a technology related career	0.189*	0.342**
	If I possess good knowledge in technology, I will be able to do lots of different types of careers	0.065	-0.019
Self-efficacy in learning science subjects	I think I am pretty skilled in learning chemistry	-0.097	-0.039
	I think I am pretty skilled in learning physics	0.099	-0.003
	I think I am pretty skilled in learning biology	-0.084	0.014
Other	Chosen science track in gymnasium	0.027	0.065

*p ≤ .05, ** p ≤ .01. All given predictors accounted for 80% variance for boys and 59% for girls on technology-related career goals.

Based on the analysis, it can be said that the strongest predictor for boys, as well as girls, is reading technology-related information and interacting with technology-related issues (being more strongly expressed by boys) and parental expectations (*My parents would like it if I choose a technology related career*), the last being more important

for girls. Students' technology-related self-efficacy was found to be an important predictor for boys, but not for girls. Based on the results, contextual support factors such as existing role models in- and outside family, provision of relevant information by school and teachers' encouragement played only a minor role in predicting students' technology related career goals.

Students' mean responses, gained from the questionnaire conducted after teaching the modules, were compared with the initial data (presented in Table 3).

Table 3. **Paired samples t-test on students' responses to the statement „I plan to work in my future career in a technology related field".**

		Boys N=145	Girls N=151	Total
Mean (SD)	Before	3.47 (0.99)	2.52 (1.00)	2.98 (1.01)
	After	3.84 (1.01)	3.62 (0.95)	3.72 (0.99)
Mean change		0.37*	1.10**	0.74**

*$p \leq .05$, **$p \leq .01$

As seen from Table 3, students' agreement with the statement *I plan to work in my future career in a technology related field* became stronger after the intervention. The change was statistically significant for both, boys as well as girls, but was more strongly expressed by girls.

Discussion

This study has three main objectives: (1) to examine gymnasium students' technology-related career orientations, (2) to identify factors that may explain their career goals, and (3) to find out whether it is possible to increase students' interest towards careers within the field of technology. Boys' and girls' results are considered separately and compared with each other as based on the literature (e.g. Eccles, 2007), gender is a substantial factor in the development of personal interests and one's career decisions. The Social Cognitive Career Theory accompanied by other studies is used to gather data and interpret the results.

The current study obtains unsurprisingly similar results with other studies conducted with various students' age groups regarding gender specific background factors related to technology and technology careers. It is reconfirmed that males have significantly stronger interests towards technology (Bame, Dugger, de Vries, & McBee, 1993; Boser, Palmer, & Daugherty, 1998; Mawson, 2010), have higher parental expectations related to careers in male-dominated fields such as e.g. technology and engineering (Seymour & Hewitt, 1997), and finally that males' future career goals are significantly more connected with technology than those for females (OECD, 2008; Jenkins & Nelson, 2010). The last finding is in accordance with findings that male students tend to prefer occupations that provide opportunities to manipulate physical objects and abstract concepts (Eccles, 2007) and invent new things (Søjberg & Schreiner, 2010), activities that are generally seen as part of technology and engineering. On the other hand, girls' tendency is to choose occupations where they can work with people and help the others (Teppo, & Rannikmäe, 2008; Sjøberg & Schreiner, 2010) or contribute to sustainable development and protecting the environment (Cerinsek, Hribar, Glodez, & Dolinsek, 2013). This may not in principle, exclude technology and engineering from one's list of favourite occupations as many engineers and technologists work with the problems that are related to urgent human needs (e.g. design of artificial arms). Still, students' inaccurate or poor information about the nature of different careers (e.g. Lavonen, Gedrovics, Byman, Meisalo, Juuti, & Uitto, 2008) go hand in hand with prevailed stereotypes of engineers and technologists as nerds who focus only on mechanical tasks with little human relevance (Eccles, 2007) and may, at least partially, explain the low popularity of technology careers amongst girls.

The findings that girls have less tendency to believe that they are able to do well in activities related to technology and secondly, obtaining good knowledge in technology enables them to enter different careers within the field of technology, can be partially explained by Eccles (2007) statement that commonly held stereotypes about gender differences (including parents' gender-differentiated expectations) „are likely to lead females and males to have different estimates of their own personal efficacies for physical sciences and engineering" (p. 202). The same tendency reflects itself already during the basic school mathematics and science studies: even when having

comparable results with boys, girls in a number of countries tend to have lower self-efficacy in their subject skills (OECD, 2007; OECD, 2013).

In the current study, teachers in the eyes of students do not seem to play a role in strengthening traditional sex stereotypes (that tends to see technology careers as only for males) as the difference between boys' and girls' responses to the statement *My teachers have encouraged me to choose a career in the field of technology* is very small (still in favor of boys). According to the results, teachers tend to play a relatively modest role in encouraging students towards technology related careers which, however, may be an underused potential as, based on Jacobs and Eccles (2000), children and youngsters construct their own interests, values and choice priorities based on messages from a variety of socializers, including their teachers.

As shown before in this paper, personal interest, interpreted as a relatively stable tendency (Krapp & Prenzel, 2011) may, in turn, be influenced by self-efficacy and outcome expectations one holds towards the same field (Lent, Brown, & Hackett, 1994). All together, directly or indirectly, these predict one's career goals within the same field (Lent, Brown, Sheu, Schmidt, Brenner, Gloster, Wilkins, Schmidt, Lyons, & Treistman, 2005). Amongst these psychological constructs, one's self-efficacy is found in many studies to be the most significant factor in predicting students' career goals in the same area (e.g. Lent, Brown, Sheu, Schmidt, Brenner, Gloster, Wilkins, Schmidt, Lyons, & Treistman, 2005; Lent, Lopez, Lopez, & Sheu, 2008). Based on the results of the current study it shows that the strongest predictor for boys, as well as girls career goals related to technology, is their interest towards technology (reading technology-related information and interacting with technology-related issues) which stresses the central role that interests play in one's career decisions. Still, students' technology-related self-efficacy is found to be an important predictor for boys, but not for girls. Thus, it can be said, that the current study only partially confirms the previous findings referred to earlier. This discrepancy can still be explained by the assertion of Betz & Hackett (2006) that the SCCT model is quite specific to a domain of behaviour (whether it is related to science, engineering, mathematics or social studies) and the context of the study (students' age group, gender, etc.). In addition, girls may be influenced by prevailed social norms that see technology careers as wholly masculine (as discussed previously), even if girls like dealing with, or read about technology. Plus the fact that STEM studies amongst the other fields are anyway considered as generally difficult (Aschbacher, Li, & Roth, 2010). It is surprising in the current study that self-efficacy in learning science subjects, as well as choosing a science track in gymnasium (identified as students taking advanced courses in science and mathematics subjects), are not significant predictors of students' technology-related career goals. The last can be explained by the peculiarities of the Estonian educational system, where notwithstanding the chosen stream in gymnasium (science, humanities or social), students tend to study substantial compulsory subjects (including science subjects, mathematics, languages, history). This generally means that even when a student has made a choice e.g. the social track, s/he may enter a career field related to science and technology, or vice versa. From the science track, it is possible to choose history, languages, etc. as areas for further studies and a career.

Parents' expectations towards choosing a technology related career play a stronger role in predicting girls' career goals and to lesser extent, boys' goals. The last finding coincides well with the OECD report (2008) according to which girls choices are, more than boys, related to expectations of their parents when choosing a career. A similar tendency is found in the study conducted by Cerinsek, Hribar, Glodez, and Dolinsek (2013) according to which mothers influence females' choice of studying STEM significantly more than males' choice.

Based on the SCCT, social supports and barriers relate to career goals directly, as well as through self-efficacy and outcome expectations (Lent, Brown, Sheu, Schmidt, Brenner, Gloster, Wilkins, Schmidt, Lyons, & Treistman, 2005). Social support indicators that are tested in the current study are: (a) provision of relevant information by school about and (b) teachers' encouragement towards, technology related careers. As it turns out, neither of these play a significant role in predicting students' technology related career goals. Therefore, it is suggested by the authors that school education generally and STEM teachers particularly needs to put more emphasis on students' career awareness. As many teachers at school may not be prepared to actually address these challenges, more intervention programmes may be needed to help teachers to become more knowledgeable. Taking into account the role that parents (especially parents of girls in the current study) play in determining one's career decision, more outreach activities therefore need to be provided by local communes or other communities of practice, in collaboration with schools or independently, to raise the career awareness of parents and public more generally (as is also proposed by Aschbacher, Li and Roth (2010)).

The intervention in the current study was particularly geared to influence students' awareness about and interest in careers in technology and engineering. As a result of the intervention where teachers took part in the

in-service programme and implemented design-based modules in their classrooms, students' career goals related to technology (including engineering) became stronger. The finding that the change was more strongly expressed by girls could be explained, first, by the context of the learning modules expected to attract especially girls or being equally attractive for both sexes. Secondly, students in the current study had the possibility to become „engineers" through a design-based science learning approach introducing a range of careers, different aspects of these careers and to persons working in the field of the given DBSL modules (the ability to raise students awareness by the same DBSL modules was already shown by the previous study of Vaino, Vaino, & Rannikmäe (2015)). And finally it could be speculated by the authors, that the in-service programme with in-depth teacher involvement and close collaboration between the participants plus provision of relevant learning materials helped them to familiarise the integrated STEM approach and implement it in their classrooms. Still, the last statement needed further confirmation and would be reported elsewhere.

Conclusions and Implications

Based on the results of the current study, it was found in the pre-intervention, that boys had significantly stronger technology-related future career goals and greater background indicators (reading more technology related information, dealing more with technology issues, having more role models in technology field and higher parents expectations related to careers in technology) than girls. The strongest predictors of boys' future career goals in the field of technology was found to be perceived self-efficacy in technology-related activities, while the strongest predictor for girls was parental expectation to enter a technology-related career.

As a result of the intervention, students' technology-related career goals became significantly stronger for both boys, as well as for girls, but being more expressed by girls. It was assumed this was a result of the suitability of the implemented learning modules which paid special attention to students' existing interests when choosing a context for a module, plus raising students' awareness of the possible careers in the field of technology. Still, there was a need for further exploration to find out which aspects of the intervention particularly helped to elicit this change (what is the mechanism of change) and whether the change was long enough to influence students' real career choices after graduating the gymnasium.

It was also suggested that when teaching STEM subjects, more emphasis should be given to integrated approaches (e.g. design-based learning approach) and also, students should be informed about the professions related to the topic, allowing them opportunities for knowledge-based (versus random) choices when graduating from school. Especially girls should be provided with positive female role-models mediated by videos, success stories or enabled by direct encounters when more female workforce was expected in STEM fields. Moreover, teachers should be made more aware about the gender differences regarding their different career expectations. In order to make a change in the classroom, teachers needed support that could be provided by specially geared in-service programmes with strong emphasis on integrated STEM approaches with explicit links to technology and engineering aspects, teacher collaboration and in-depth involvement.

Acknowledgements

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Toomas Vaino	MSc, Doctoral Student, University of Tartu, Vanemuise 46, Tartu, Estonia. E-mail: toomas.vaino@ut.ee Website: https://www.ut.ee/biodida/e/indexin.htm
Katrin Vaino	PhD, Researcher, University of Umeå, Förvaltningshuset, Universitetstorget 16, 901 87 Umeå, Sweden. E-mail: katrin.vaino@ut.ee
Miia Rannikmäe	PhD, Professor, University of Tartu, Vanemuise 46, Tartu, Estonia. E-mail: miia.rannikmae@ut.ee Website: https://www.ut.ee/biodida/e/indexin.htm
Jack Holbrook	PhD, Professor, University of Tartu, Vanemuise 46, Tartu, Estonia. E-mail: jack.holbrook@ut.ee Website: https://www.ut.ee/biodida/e/indexin.htm