Developing IT skills in Estonian schools

Study report

This study has been conducted on behalf of TransferWise by the researchers of Institute of Education and Institute of Computer Science of Tartu University

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Summary

The labour market has a high demand for employees with IT (information technology) skills. At first glance, students' interest in IT learning seems to be high, as there is a competition for IT curricula programmes every year at higher education institutions. However, a significant number of IT students discontinue their studies in the first year of study because they chose the wrong speciality for themselves. As the choice of speciality is made before enrolling in an institution of higher education, this research focuses on activities taking place in basic schools and upper secondary schools, which influence the choice of students to continue their studies in IT specialties. This report gives an overview of the research carried out on behalf of the IT company TransferWise to examine what is being done in Estonian schools to motivate students to study IT and help them see their future in IT through an informed choice.

During the research, data was collected using a questionnaire from 740 students in grades 9 and 12 and from 27 school employees who were e.g. IT teachers, principals or educational technologists. Additionally, six schools were visited, their learning environments were observed and interviews were conducted with 17 students of the final grade and 8 IT teachers.

The results show that nearly all students participating in the research have taken part in computer science or information technology classes. Slightly more than half of the students have pursued programming and, less than a third, robotics. 37% of students saw their future in IT. Boys had more IT learning experiences and greater interest toward learning IT. From the interviews, students defined IT as everything related to computers, considered IT equal to programming, digitality, transferring information, and creating something with their own hands.

The IT teachers who participated in the study had very different backgrounds, and there was a difference in how IT is taught in schools and what is being done to increase students' IT interest. Best practices included the use of virtual reality glasses and interactive floor in classes, integrating 3D printers and robotics into subject classes, a programming group for girls, and teaching different programming languages at upper secondary school.

This report concludes with recommendations for what can be done in schools to give a better overview of IT to students and to motivate students to study IT.

1. Introduction

Over the past few decades, there has been a growing demand for people with STEM (science, technology, engineering, mathematics) skills and knowledge. The field of STEM includes information technology (IT) related skills, and research has shown that in many countries, there is a shortage of people with IT skills (Hüsing et al., 2013; Gareis et al., 2014). On the other hand, a large number of students every year are enrolled in IT programmes in Estonian institutions of higher education which indicates that there is an interest in studying IT.

The interest toward studying IT in institutions of higher education seems to be strong but the ratio of graduates finishing their studies has been declining for some time (Gareis et al., 2014), and consequently, there is a lack of IT employees in the labour market. In the European Union, the average dropout rate in IT-related specialities is approximately 19% (Hüsing et al., 2013), in Estonia, however, it is even higher. The calculations based on the data of Estonian Education Information System (EHIS, 2015) show that already in the first year, the dropout rate for students in IT specialities is 29.8%. This is significantly higher than in other specialities in Estonia where the average dropout rate for students in the first year is 18% (calculations based on EHIS, 2015).

One of the main reasons to discontinue studies is the wrong choice of speciality (Altin & Rantsus, 2015). The speciality has been generally already chosen in the general education school where the experiences of studying IT are one of the reasons why it is desired to continue IT studies in an institution of higher education (McGill, Decker & Settle, 2016). In addition to academic experience, making a career choice that is related to IT is also affected by social support and self-efficacy (Rosson, Carroll & Sinha, 2011), opportunities in the labour market (Divjak, Ostroski & Palma, 2010), etc. To make sure that the students enroll in IT related programmes having an adequate overview of what these studies entail, and that they are ready to finish their studies and start working in the IT field, it is necessary to investigate what takes place on the level of general education schools.

To ensure the sustainability of the field of IT, this research places its focus on Estonian general education schools to find areas that could be improved so that students make a right choice of speciality in the field of IT. As IT education varies from school to school and there is no unified curriculum, students from different schools receive different preparation which may affect their choice to continue studies in the field of IT. The goal of this research was to first establish an overview of activities in Estonian schools that could motivate students to study IT and to help them see their future in IT. The second goal was to provide a set of recommendations about what could be done in Estonian schools to motivate making an adequate choice in favour of an IT related speciality.

In this study, we define IT as creating something (such as programming, web design), software testing, database management, hardware management, etc. Here, IT doesn’t encompass text and table editing, gaming, social media, etc. IT skills belong under STEM skills and for this reason, we broadly review the teaching of STEM skills in general education schools. STEM skills also comprise, in addition to IT related skills, the skills falling under the mathematical, nature sciences, and technological competencies in the national curricula of basic school and upper secondary school, which include inquiry skills, mathematical problem solving skills and computational thinking skills.

2. Previous studies in Estonia

Previously, an assortment of studies has been carried out in Estonia where the focus has been placed on teaching IT and digital skills in general education schools, as well as teaching students studying in IT programmes in universities.

A study examining the teaching of digital skills has been carried out on behalf of Information Technology Foundation for Education (HITSA) in general education schools and preschools (Leppik, Haaristo & Mägi, 2017). In this study, the results showed that the level of teaching in regard to digital skills in general education schools is uneven and the role and amount of digital skills included in different curricula vary greatly. The attitudes of teachers and students toward using digital tools are positive, but still, digital tools are not used to an adequate extent in the teaching environment. Main obstacles in teaching digital skills included the lack of availability of digital tools (equipment, environments, software) and digital study materials of high quality. Based on this, the current study presents questions to IT teachers requesting information about anything that is lacking within the context of their IT teaching in school.

A study focusing on the possibilities to improve knowledge, skills, and attitudes toward the cyber domain and startup companies has been conducted, showing that many teachers are not able to keep up with the development of technology (*Tuleviku tegija teekond startup ökosüsteemi*, 2018). Similarly to the previous study, the results indicated that technology is seldom integrated to study classes. The playful nature is what attracts the young to the cyber domain and it could be used more in educational work. Generally, both boys and girls in preschool and elementary school have an interest toward the digital world but at around ages 10-13, the boys' interest toward the subject rises significantly while the girls' interest might even decline. The students of basic school and upper secondary school who are interested in the cyber domain are more likely to pursue this interest outside of school and think that the computer science classes in school are taught at a level that is not high enough. Based on this, the current study presents questions to students about studying IT both in and outside of school.

Globally, women represent a minority in the field of IT and consequently, many studies have been conducted to examine the role of women in IT. In Estonia, just 22% of IT domain is represented by women (Jürgenson jt, 2013) and we've also had studies examining the role of women in IT and the possibility of increasing it (see Kindsiko, Türk & Kantšukov, 2015). In the mentioned study, it was found that the obstacles in the way of increasing the role of women in IT include cultural-gender attitudes, ICT general education, individual and extra-individual barriers related to ICT. In regard to general education schools, a problem presents itself where in some schools, the boys are encouraged to take programming lessons and the girls are recommended to take drawing, photography, etc. classes. There is also an understanding prevalent within students that IT is only programming, and in reality, they lack the picture of the broad opportunities available in the field of IT. Due to the minority of women in IT, this study compares the answers of boys and girls to see if there are any differences.

To study the career choices of IT students in higher education institutions and IT studies therein, a project titled „Conceptual framework for increasing society's commitment in ICT: approaches in general and higher education for motivating ICT-related career choices and improving competences for applying and developing ICT" has been carried out. In the project report, titled „What happens to IT education in Estonia?", a variety of recommendations are provided to promote IT education in different target groups: students, IT students in higher education institutions, parents, general education schools, higher education schools, IT companies and policymakers (see What happens to IT education in Estonia?, 2015). To improve IT teaching in general education schools, the recommendations of the report include enabling all students to study programming in school and to offer possibilities for the more talented to take courses outside of school, to integrate IT and programming into other classes, to get the career counselors give better overview of different IT specialities, to host visitors and visiting teachers from IT companies and to offer additional IT related training to teachers.

In the framework of the mentioned project, the people who apply to higher education institutions to IT specialities and the students who were studying in different IT programmes, were examined. The main results indicated that when applying to IT specialities in higher education institutions, the main reason for applying was the interest toward IT (Kori et al., 2014) and the roots of this interest trace back to an experience of creating something on own (e.g. solving problems related to computers, building a computer, programming, creating a computer game, etc.) (Kori et al., 2015). This experience of creating independently usually starts in basic school or even earlier. Luik et al. (2019) found that this interest is one of the main reasons why people participate in MOOCs (Massive Open Online Courses). In addition to interest, the assessment of own abilities and usefulness of it for the future were also important factors. Motivation to study IT in higher education institutions has also been studied by Säde et al. (2019), who found that the most important factors for the first year IT students for motivation included inner value and usefulness; the least important factor was social pressure. Based on these previous studies, this study also examines the motivation of basic school and upper secondary school students in relation to studying IT.

In Estonia, the role of academic, social and professional integration of IT students during their studies in higher education institutions has been examined (see Kori, 2017). In this study, academic integration was defined as how the student was connected to the studies (e.g. his or her academic outcomes), social integration was defined as what were the relationships the student has with his or her fellow students and teaching staff, and professional integration was defined as how the student is associated with working in the field of IT. The results of the study indicated that when starting IT studies, the most important factor of the three was academic integration, the role of social and professional integration did not play a large part in comparison. During the studies, however, the role of professional integration increases and students think that if they could start working during the studies, it would help them to finish their studies. This means that IT students want to associate themselves more with practical work. Based on this study, the current study examined the academic, social, and professional integration of students.

Still, there are many IT students in higher education institutions who discontinue their studies. Altin and Rantsus (2015) concluded phone interviews with IT students who had dropped out of institutions of higher education and found that the first year studies were mostly abandoned due to a mismatch of the speciality for the student who wanted to study something else. 40% of the participants were enrolled in some other speciality a year after starting IT studies. Kori and Mardo (2017) compared the experiences of the students who discontinued their studies and those who continued their studies and found that independent study of ICT before enrolling in a higher education institution makes the studies easier once enrolled. Other studies have also found that experience of learning programming before enrolling in an institution of higher education will grant an advantage during the studies (Hagan & Markham, 2000; Kori, Pedaste, Leijen, & Tõnisson, 2016). On the other hand, the motivation of students who have finished a programming MOOC before enrolling in an IT speciality in higher education institution does not differ from the motivation of those students who have not participated in programming MOOCs (Säde et al., 2019). Additionally, the students in upper secondary schools receive programming experience that is significantly varied in nature, and after analysing 16 courses it was found that 14 different programming languages are used (Puniste, 2015). Based on this, the current study examines the experiences of students in basic and upper secondary schools in relation to studying IT in general education schools which affects their perception of the field of IT and their wish to bind themselves with IT in the future.

3. Teaching IT in schools

In the introduction, we defined IT (in the scope of this study) as creating something (such as programming, web design), software testing, database management, hardware management, etc. This is also the definition we use when we describe the situation in schools and which is why the study does not encompass the use of computers on a basic level (e.g. text and table editing, etc.) nor the use of information technology in studying other subjects (e.g. educational software).

Teaching information technology reached Estonian schools in 1962 when Ülo Kaasik started to teach programming (in machine code) in the first special class of mathematics in Tartu Secondary School No.1 (now Hugo Treffner Gymnasium). In the 1960s and ’70s, programming was taught to relatively few students in special classes in some schools in Estonia. This reflected the general situation of the whole circle of socialism and capitalism as it was then called. The use of computers meant, first and foremost, programming and it was the opinion of visionaries that in the future, everyone should be able to do so. Thus programming received the name of „the second literacy skill“ in the Soviet Union. There were a few computers and some programming was taught using a regular blackboard and paper.

In the 1980s, computers started to reach more schools. As there was now a possibility to do things with the computer other than programming (e.g. text and table editing), a new question was brought up as to whom and how much programming should be taught to. This question has actually been relevant up to this day. There were now enough youngsters having a deeper interest in programming that since 1988, an informatics olympiad has been regularly held where the aim is to solve programming tasks.

The operations of schools are largely directed by the national curriculum. In the national curriculum of 1996, a direction leading away from programming was adopted – it was no longer important to teach programming to many or everyone. The national curricula that followed also did not strongly highlight the teaching of programming. The national curriculum of upper secondary schools that is valid today has an optional course in natural sciences named „Basics of programming and development of software applications“. Some other optional courses from that list are relevant in the context of this report: „Mechatronics and robotics" and „3D modelling". One course in upper secondary school is 35 academic hours. No programming or similar subject is provided in the national curriculum for basic schools.

Although the national curriculum is important, it does not determine everything taught in schools. For example, some optional courses set in the national curriculum are not necessarily taught in schools. At the same time, entirely different courses might be offered to the students. Additionally, students may acquire knowledge and skills as extracurricular education.

Schools, upper secondary schools in particular, can offer an assortment of studying possibilities for students and, using an example of information technology, schools are very different from one another. There are schools where the students have diverse options pursuing activities related to IT and there are schools where these options are basically non-existent.

There are two larger studies that discuss the situation at schools: Leppik, Haaristo & Mägi (2017) and „What happens to IT education in Estonia?“ (2015). The following draws conclusions from these two studies.

Different schools offer different IT themed subjects and courses. In basic school, these subjects mainly comprise „Informatics“ and „Computer Science“, the content of which varies greatly. In a few schools, „Robotics“ and „Programming“ are also taught as subjects.

The upper secondary schools have even larger autonomy and so a variety of courses is held. These include „Informatics“ (and to a lesser extent, „Computer Science“) courses which may contain IT-related topics in the meaning of this study (programming, robotics, etc.). The course of „Programming“ took place in 2007 in 17% of schools, „Robotics“ was held in 16% of schools, the course listed in the national curriculum, „Basics of programming and development of software applications“, was held in 12% of schools. Some additional programming courses with different titles can be found in schools. The courses offered at schools are quite different; for example, when looking just at the programming languages, they included over dozen of these in 2015 (e.g. C, C++, C#, Java, JavaScript, Logo, MIT AppInventor, Perl, PHP, Python, Scratch, Turbo Pascal, Visual Basic). An important thing to consider here is that even when a subject or course is held in a school does not mean that every student will pass it.

Extracurricular education plays a large role. In 2017, 68% of Estonian general education schools had hobby groups related to IT. A large portion of IT hobby groups pursue robotics and mechatronics (55% of IT hobby groups) and programming (38%). There are many contests held in robotics, both regionally and statewide (e.g. First Lego League“, „Junior First Lego League“, „*Võru Tsõõr ja RoboMiku lahing* (The Battle of Võru Tsõõr and Robomiku)“, „Robotex“). Also held are the informatics competition titled „*Kobras* (Beaver)“ and informatics olympiad.
The students have an option to participate in massive open online courses (MOOC). These courses enable students to examine their interests and reach the conclusion whether the continuation of studies in computer science/information technology is feasible for them (Zheng, Rosson, Shih, & Carroll, 2015). The MOOCs carried out by the Institute of Computer Science of Tartu University, namely „Down-to-earth Programming“, „Programming Basics“ and „Programming Basics II“, have had a student pass/participation ratio of 494/858, 295/812 and 58/130, respectively.

Some other events take place in schools that introduce IT to students, e.g. theme days, tours, visitors.

The autonomy of schools in choosing their subjects/courses can be considered as positive on one hand, but on the other hand, a certain central management would save resources and raise the level of quality. A new concept for basic schools has been worked out by HITSA, titled „New topics of education in the basic school syllabus of informatics to support acquiring the up to date IT skills (*Uued õppeteemad põhikooli informaatika ainekavas nüüdisaegsete IT-oskuste omandamise* *toetamiseks*)“. New digital textbooks have been compiled for school stages of study I and II, which include the topics „Code“ and „Programming“. A new concept for the upper secondary school sets forth a preparation of five new courses. These courses (each 35 academic hours) are „Programming“, „Software development“, „Software analysis and testing“, „User-centered design and prototyping“, and „Digital services“. It is envisioned that different students pass different courses, and later, as a group assignment, complete a development project for a digital solution. At this point in time, study materials are being prepared and pilot courses are being carried out.

4. Methodology

To collect the data, both quantitative and qualitative methodologies were used. Data was initially gathered using questionnaires, from the schools who answered the questionnaires, six schools were chosen to carry out observations and interviews in. The following subchapters include a description of how and which data were collected using questionnaires, interviews, and observations.

4.1. Quantitative data collection

Two questionnaires were designed to collect the data. One was prepared for the students of grade 9 or 12, and the other for the school staff who have an adequate overview of IT teaching in school (e.g. IT teacher, principal, educational technologist).
The student questionnaire included the following:

- background information (e.g. school, grade, gender),
- experiences related to studying IT (e.g. the participation in informatics/computer science classes and the content of these classes, experience with learning programming and robotics, experience with visiting IT companies),
- motivation to study IT (items regarding the following aspects of motivation: study experience, self-efficacy, intrinsic and extrinsic motivation, interest toward profession, social pressure, perceived abilities, altruistic motivation) and academic, social, and professional integration related to IT.
- seeing their future in IT (e.g. whether, and if so, then in which manner the student sees their future related to IT).

The IT teacher/principal/educational technologist questionnaire included the following:

- background information (e.g. school, job position, teaching at which study stage),
- experience of teaching IT (in the case where the respondent was an IT teacher) (e.g. has s/he studied to be an IT teacher, how long has s/he taught IT, how many hours per week s/he teaches),
- teaching IT skills in school (e.g. what are the contents of computer science/informatics classes, how many different IT courses the students and IT teachers need, which activities are taking place in schools that heighten interest toward IT),
- teaching STEM skills (e.g. how is the teaching of STEM skills organised, how much attention is given to various STEM skills being taught),
- interest and opportunities of students to study IT (e.g. what kind of interest do students have toward IT, how much do the students see their future in IT, which possibilities do students have for studying IT at school).

The schools which may have positive examples of how IT is taught at schools and how to increase the students' interest toward IT were invited to participate in the study. In order to accomplish this, the schools which had received a golden recognition by HITSA were contacted along with upper secondary schools which had a field of study of IT in the school programme. Initially, the principal was contacted and if s/he agreed, the school participated in the study. The questionnaires were completed by the students from 25 schools who were studying either in grade 9 (in the case of a basic school) or in grade 12 (in the case of an upper secondary school), and one to two school employees. The participants in the study included students from final grades as they soon face a choice whether to continue studying, and if so, what to study. As certain schools were purposefully elected to participate in the study and the goal was to find schools where teaching IT takes place on the highest level, this study does not give an overview of the situation in all Estonian schools and this must be considered when interpreting the results.

A total of 740 students completed the student questionnaire. Of the respondents, 156 were grade 9 students (from 6 schools) and 584 were grade 12 students (from 19 schools). Among the respondents, there were slightly more girls than boys (55.1%). The questionnaire designed for IT teacher/principal/educational technologist was completed by 27 people from 25 schools. Of the respondents, 21 were IT teachers, 4 were principals, 8 were educational technologists and 4 picked the option „Other" (e.g. ICT manager, teacher of another subject, etc.)(the respondent also had the possibility to pick several options). Of the IT teachers, 15 taught at upper secondary school, 10 at the third stage of study, 9 at the second stage of study, and 3 at the first stage of study (the respondent also had the possibility to pick several options).

To analyse the data, the following software were used: MS Excel, IBM SPSS Statistics 25 and Mplus. Mann-Whitney U test was used to compare two groups (e.g. boys and girls or grade 9 and grade 12 students), Wilcoxon test was used to compare two variables (e.g. reported interest after visiting IT companies), and both exploratory and confirmatory factor analyses were used to analyse the items of motivation.

4.2. Qualitative data collection

To collect qualitative data, semistructured interview questions were prepared for both the IT teachers and the final grade students (grade 9 or 12). Due to a strong interest toward IT, a few students from grades 8 and 11 were elected to participate, as well.

Six schools were chosen from the schools participating in the questionnaires to carry out interviews in. When choosing the schools to be included, the answers of students to questions in regard to the following were particularly examined: how much had they studied computer science, programming, and robotics, and how much do they see their future being related to IT; and the answers of teachers in regard to IT-related activities in school, turning attention to STEM skills, and students' interest and possibilities to study IT. For interviews, the schools were chosen in a way to maximise the differences between them, for example, the schools where the students have more experience as well as the schools where the students have less experience. When choosing schools, additional consideration included the fact that the schools should be located in different regions all over Estonia.

During the interviews, the students were asked about the following topics:

- visits of IT companies to the school and their effect on the interest and motivation,
- interest and motivation toward the field of IT,
- studying IT in the future,
- their perception of the field of IT.

During the interviews, the IT teachers were asked about the following topics:

- ICT tools and learning environment at school,
- best practices when teaching IT and increasing students' interest toward IT.

Schools were visited to carry out the interviews, where in addition to conducting the interviews, the learning environment in which the IT teaching takes place was examined.

In the case of all schools, one person was used to carry out the interviews who visited the school and interviewed the IT teacher and up to four final grade students. Interviews were carried out with one person at a time, and in total, 17 students and 8 teachers participated. Interviews were transcribed and analysed using inductive content analysis.

5. Results

5.1. Experiences studying IT

First, the students were asked about their experiences learning IT. The students in both grade 9 and 12 mostly answered that the classes of informatics or computer science (including programming) had been taking place for 2-3 years (during 2-3 grades). There were more students in grade 12 who had had these classes for 4-5 years or 6 and more years which probably derives from the fact that grade 12 has been attending school for longer. Still, there were more students in grade 12 than in grade 9 who answered that they have not been taking any informatics or computer science classes on any year. There were upper secondary schools in the study which included the field of study for IT but there were also grade 12 students from other fields of study. It is possible that there are fields of studies where no informatics or computer science is taught in, and the students, when responding, may have not considered that they had taken these classes in basic school.

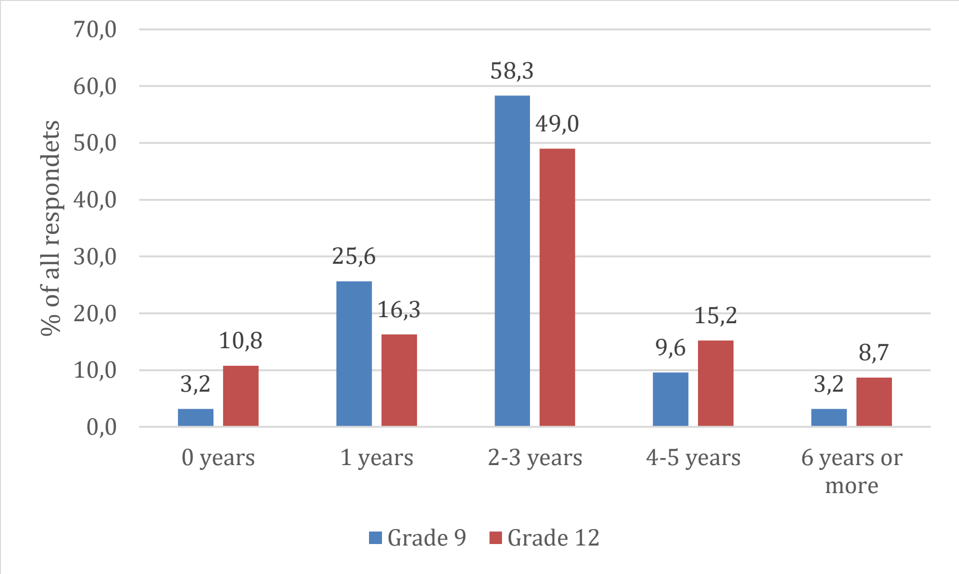

Figure 1. For how many years have the students participated in informatics or computer science (incl. programming, etc.) classes?

To get an overview of what the students have learned in informatics or computer science classes, both the students and the teachers were given choices of different IT-related courses. Figure 2 contains an overview of the topics that are included in informatics or computer science classes in the opinion of both students and teachers. Students and teachers agreed that the content of these classes mostly included text and table editing and information searching and it least included software development, user-centered design and prototyping, and software analysis and testing. In the current study, we defined IT as independently creating something (such as programming, web design), software testing, database management, hardware management, etc., but not text and table editing, computer gaming, social media, etc. However, the main content of informatics or computer science classes included text and table editing which does not fall under the definition of IT in this instance. A statistically significant difference became apparent for several topics between the answers of students and teachers. Teachers, significantly more often than students, claimed the following topics being the content of informatics or computer science classes: programming ($p<0.01$), digital services ($p<0.01$), robotics ($p<0.01$), multimedia ($p<0.01$), 3D modelling ($p<0.01$), cyber security ($p<0.01$), hardware ($p<0.01$), using subject-specific software ($p<0.01$). It could be reasoned that the information given by teachers, describing the content of informatics or computer science classes, is more comprehensive than that of the students. A student may not always perceive the area in which the activities carried out in class fall under.

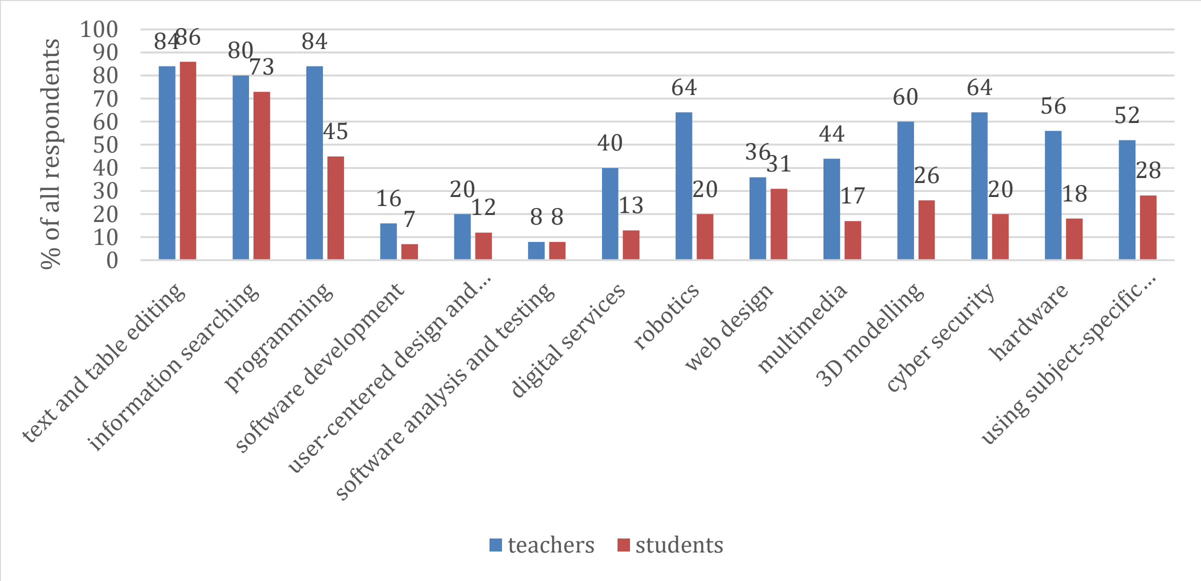

Figure 2. The content of informatics or computer science classes as perceived by students and teachers.

Students were asked to assess these same IT courses in terms of whether they would like to participate in them. The results showed that students mostly want to study programming (45.1%) and web design (44.5%). After that, the following courses are listed in descending order from the highest to the lowest interest to participate in: 3D modelling (30.8%), software development (29.9%), multimedia (24.2%), cyber security (24.1%), user-centered design and prototyping (23.8%), digital services (18.0%), software analysis and testing (17.8%), and lastly, robotics (15.8%). There were also differences between the answers of grade 9 and 12. Namely, grade 12 students wanted more than grade 9 students to study web design ($p<0.05$), cyber security ($p<0.05$), multimedia ($p<0.05$) and digital services ($p<0.05$). In the case of the several following courses, boys wanted statistically significantly more to participate in them, compared to girls: programming ($p<0.01$), software development ($p<0,01$), software analysis and testing ($p<0.01$), robotics ($p<0.01$), cyber security ($p<0.05$). However, there was one course which interested girls more than boys. It was web design ($p<0.01$), which is, more than other courses, related to creative arts and might thus offer greater interest to girls.

Next, the students were asked about studying programming and robotics. 56.4% of grade 9 students and 57.4% of grade 12 students had studied programming. Students had mostly studied programming in school's informatics or computer science classes (see Figure 3). When comparing the answers of grade 9 and 12 students, the students of grade 12 had studied programming outside school more than students of grade 9 ($p<0.05$). When comparing the programming experience of boys and girls, the boys have pursued programming significantly more, compared to the girls ($p>0.01$). 70.5% of the boys and 46.3% of the girls responded that they have studied programming. When the students were asked to assess how many hours have they been programming (see Figure 4), it became apparent that the boys had been engaged in programming longer than girls ($p<0.01$). Another difference included the manner in which the boys and girls had learned programming. The boys had, statistically significantly more often than girls, studied programming independently ($p<0.01$), in the courses outside school ($p<0.01$) and in a hobby group ($p<0.05$). The girls, more often than the boys, answered that they had studied programming at school in informatics or computer science classes ($p<0.01$).

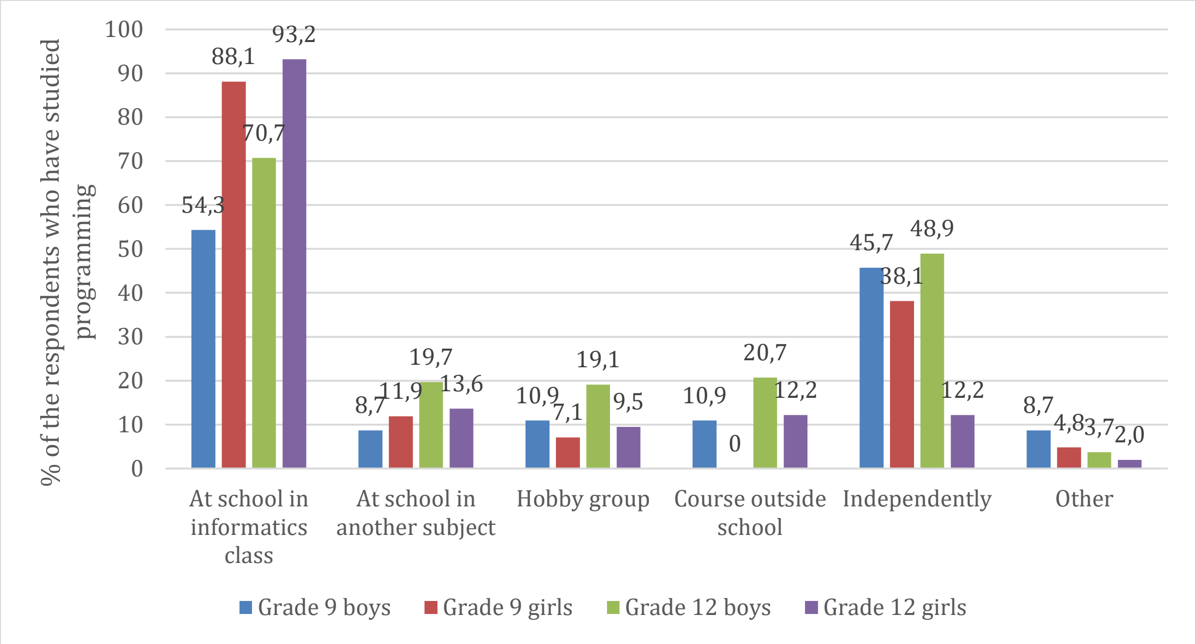

Figure 3. Where have the students learned programming?

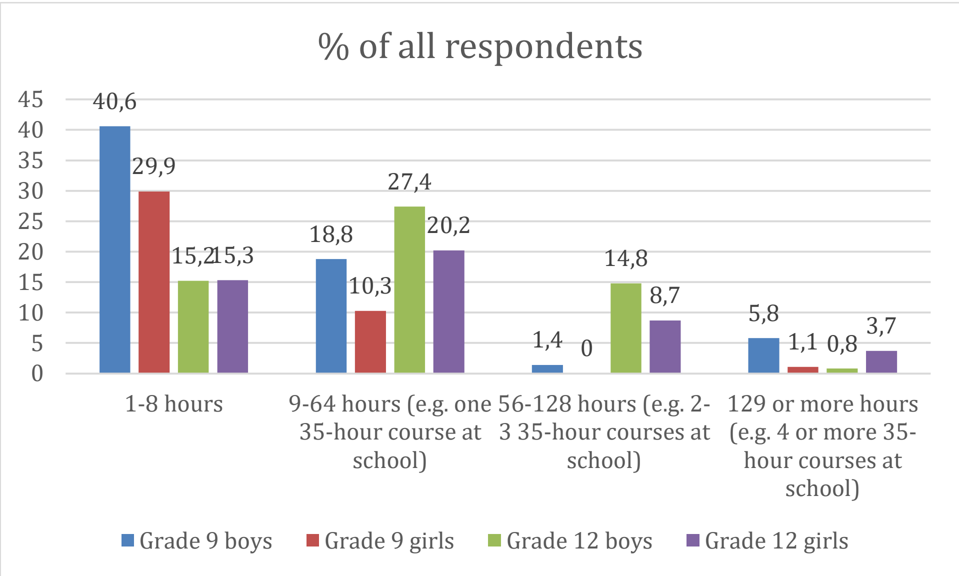

Figure 4. How many hours have the students spent programming?

The students' level of studying programming was also quite varied. When the students were asked how they would rate their programming experience, 43% responded that they know almost nothing, 20.9% responded that they have tried some on their own, 17.3% responded that they have created simple programs, 16.2% responded that they have an idea of what programming is but haven't tried it, and 2.6% responded that they have created more complex programs. When comparing the answers of boys and girls, the boys rated their programming experience higher compared to girls ($p<0.01$).

The students had studied robotics less than programming: 25.6% of grade 9 students and 30.0% of grade 12 students. The students had mostly studied robotics at school in informatics or computer science classes and in hobby groups (see Figure 5). When comparing the answers of grade 9 and 12 students, grade 9 students more often than grade 12 students responded that they have studied robotics at school in informatics or computer science classes (p<0.05) and in hobby groups (p<0.05). Grade 12 students, more often than grade 9 students, had been studying robotics in another subject at school (p<0.05). Similarly to programming, more boys had studied robotics, compared to the girls (p<0.01): 40.7% of the boys and 19.6% of the girls responded that they have studied robotics. When the students were asked to assess how many hours have they been engaged in robotics, it was also apparent that the boys had been pursuing it for longer, compared to the girls (p<0.01) (see Figure 6). The difference between the experience of boys and girls was also represented in the fact that more boys responded that they had independently engaged in robotics, compared to the girls (p<0.01).

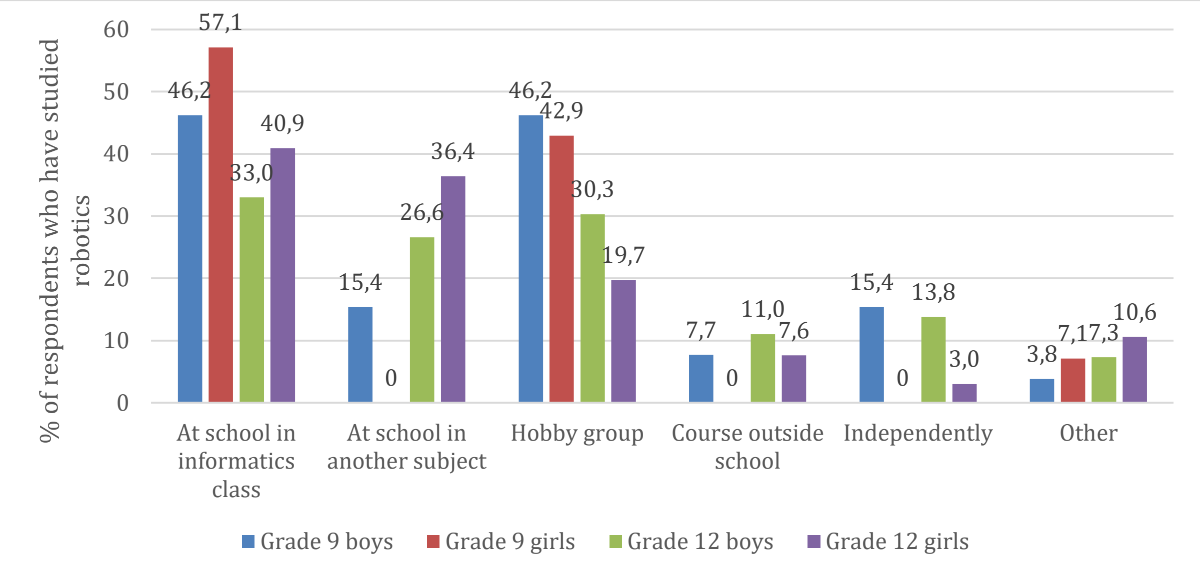

Figure 5. Where have the students learned robotics?

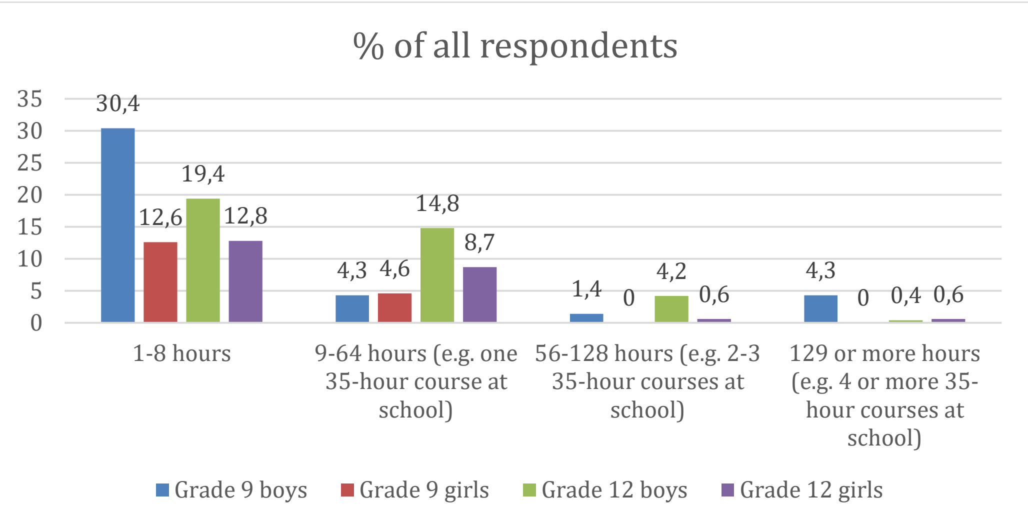

Figure 6. How many hours have the students spent with robotics?

Concerning the experience of studying IT, the students were also asked about whether they have seen IT companies speak at school and whether they themselves have visited IT companies. This was asked as having a contact with IT companies could give student a better picture of what the IT field is about and it could raise students' interest toward studying IT. The results showed that 48.4% of the students had seen IT companies speak at school. The girls, statistically significantly less compared to the boys, had seen an IT company speak at school (p<0.01), and grade 9 students had done so statistically significantly less compared to the grade 12 students (p<0.01). Even fewer students had visited an IT company themselves (29.5%), and the girls had done so less than the boys (p<0,01), but there were no statistically significant differences between grades 9 and 12 in this aspect.

The students who saw an IT company speak in school or have visited an IT company were asked how it affected their interest toward IT. The results are shown in Figures 7 and 8. Both figures display that most grade 12 boys have responded no effect on their interest toward IT. However, generally it was seen that responses of the students leaned more to the increasing interest toward IT. Particularly in the case of grade 9, it can be seen from the boys' responses that their interest toward IT has increased. In both cases, the boys' interest has increased significantly statistically more, compared to the girls (p<0.01). There were 158 students among the respondents who had seen both an IT company speak in school and have visited an IT company themselves. Comparing their assessment as to which activity affected their interest toward IT more, it becomes clear that visiting IT companies has increased the students' interest toward IT more than seeing IT companies speak at school (p<0.05).

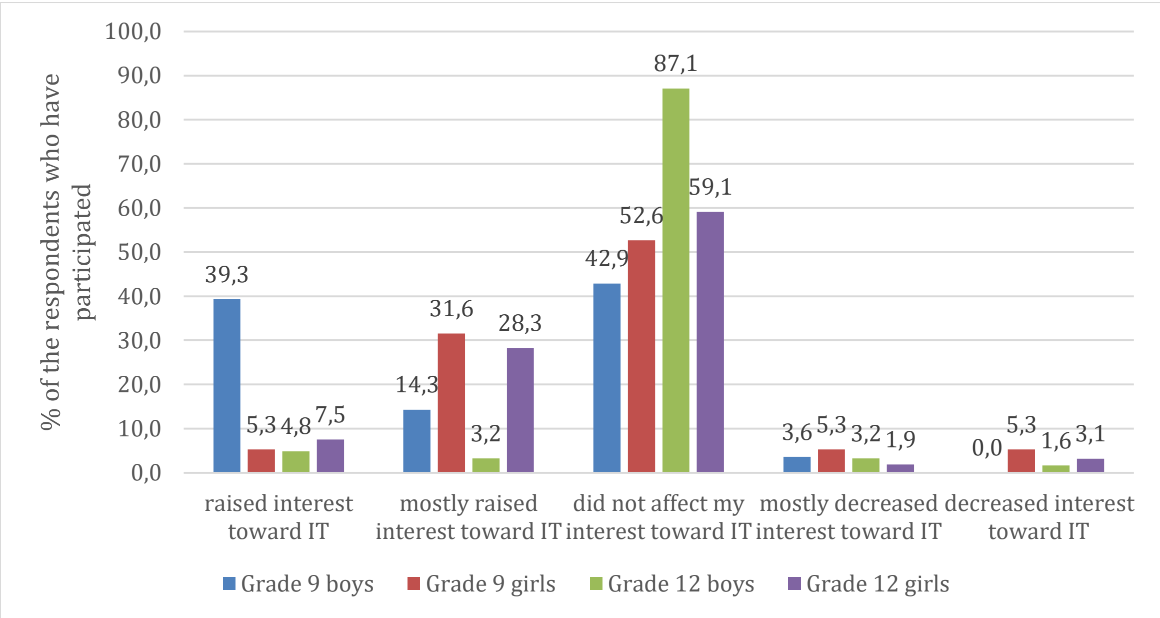

Figure 7. How the IT companies speaking at school have affected students' interest toward IT?

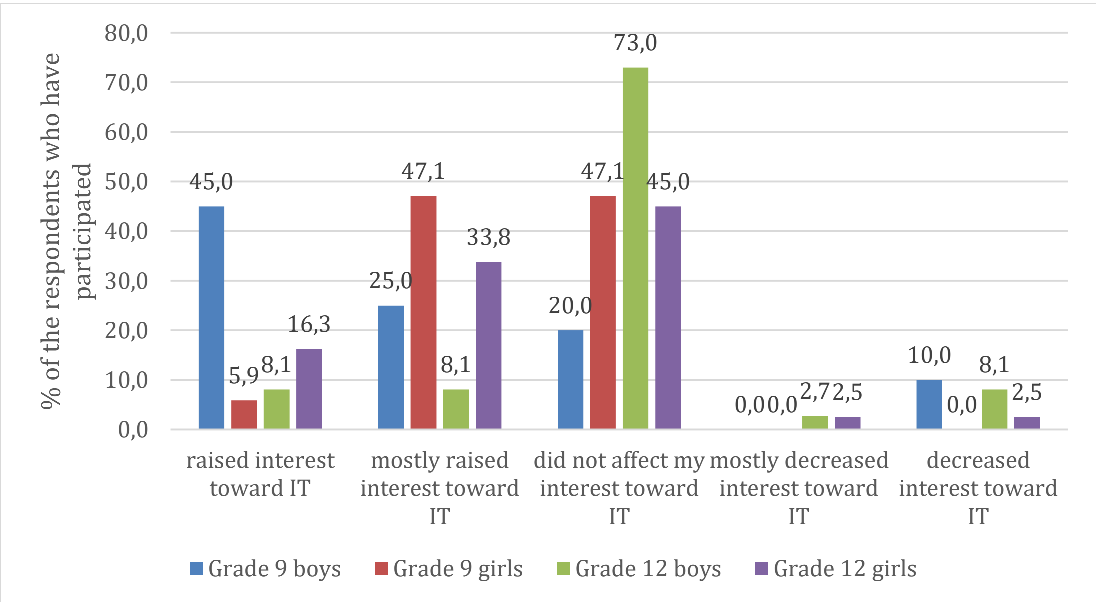

Figure 8. How the visiting of IT companies have affected students' interest toward IT?

The interviews also asked about the students' opinion how IT companies speaking at school and visiting IT companies affect their motivation toward studying IT. Students thought that the visiting of IT companies might elicit interest and inspire, if the student already has an existing interest toward it. The results from the interviews showed that five schools out of six have been visited by an IT company but all students did not participate in these introductions. Students' opinions about companies' introductions were varied:

"*If it's an Estonian company, if they can elicit interest in people and be engaging, then they would surely have an audience*."

"Those who already deal with IT they already know, I think, but they could still affect someone a little. If something is offered to me, I would probably hear them out but I don't know if it would influence me to come and work there or do something there in relation with this."

„I think that if there is no interest at all, it alone won't do anything, but if there's a small interest, that definitely helps increase the interest and show that it is a good way to life your life in a good way and for sure it's one important profession to achieve."

Some students had visited IT companies (e.g. Telia, Nortal) as part of a competition, workshop, or student company. Similarly to the results of the questionnaire, students thought that visiting an IT company in person helps to create more interest, compared to when representatives of the companies speaking at school.

"Visiting an IT company helps increase the interest, sure."

„In an IT company they can see what goes on around here, what works, what it is and how it all works. How people work."

"Within the context of a student company we met with Taxify leaders in Tallinn and it was quite interesting."

„I think that visiting a company is definitely more effective but it must include someone explaining everything about this more broadly, but when visiting a company, you get less of an impression that it's all just a big talk but you can really see that this is what life is like."

Students who had not visited an IT company were interested in doing so:

„I have not visited an IT company, maybe I wanted, but don't know. Maybe I would like to meet people who for example made Skype, how they did it, ask them about it."

Generally, students spoken to in interviews thought that talking about IT specialities in an interesting manner and seeing real life context is something that may initiate interest toward IT.

5.2. Motivation to learn IT

In the questionnaire, students were asked to rate 32 items on a 5-point scale to assess their motivation to study IT and how they are integrated into IT academically, socially, and professionally.
The items were prepared, according to theory, in a manner which divided them into 11 factors:
1) learning experience (what experience do students have related to studying IT),
2) self-efficacy (to what extent do students believe they will be successful in the field of IT),
3) intrinsic motivation (to what extent is IT related to intrinsic factors such as interest and self-development),
4) extrinsic motivation (to what extent is IT related to extrinsic factors such as good job position and good pay),
5) interest toward profession (what kind of interest do students have toward IT),
6) social pressure (to what extent do friends and family affect the decision to pursue IT),
7) perceived abilities (how do students perceive their IT-related abilities),
8) altruistic motivation (to what extent do IT skills grant a possibility to be useful for the world),
9) academic integration (does the student study IT at school and what are his/her academic outcomes),
10) social integration (do the friends and family engage in IT),
11) professional integration (is the student already or does s/he want to be connected to IT professionally).

To confirm whether the items divide into factors in this manner, a confirmatory factor analysis was carried out. The results of the confirmatory factor analysis showed that the items do not divide into 11 factors in this manner, as the model fit indices were not good enough (especially in the case of chi-squared test, TLI, and CFI). To find a fitting model that would characterise the responses of students, an exploratory factor analysis was carried out. Based on this, a 9-factor model was chosen as having the best fit. This model differed from the original theoretical model only in the aspect of professional integration which did not differentiate and the items belonging to this factor were distributed among other factors. An earlier study indicated that professional integration becomes important during the studies in higher education institutions (Kori, 2017), and the current study confirms that for grade 9 and 12 students, this factor could not yet be differentiated. The factors, items, their factor loads, and values of Cronbach’s alpha of the 9-factor model chosen as having suitable fit are shown in Table 1.

Table 1. 9-factor model which describes the students' motivation to study IT.

Factors	Items	Factor load	Cronbach's alpha
Positive learning experiences	My experiences related to studying IT (e.g. programming, robotics, etc.) have been positive.	0.629	0.717
	I've had inspiring teachers in the field of IT.	0.735	
	I've had positive experiences from IT-related competitions or projects.	0.569	
Self-efficacy	I am sure that if I would study IT, I would be successful in my studies.	0.869	0.890
	I am sure that if I would work in IT, I would be successful in my work.	0.917	
	I am sure that I would succeed in creating difficult programs.	0.783	
Value of future work	IT skills will get me a good job in the future.	0.895	0.896
	IT skills will get me a good salary in the future.	0.907	
Interest	IT is interesting to me.	0.931	0.915
	I like pursuing IT.	0.938	
	I also pursue IT outside school because it's interesting.	0.757	
	I want to work in IT in the future.	0.747	
Importance	IT skills give me an opportunity to get good results in competitions or contests.	0.591	0.836
	IT skills give me an opportunity to do interesting work in the future.	0.800	
	Studying IT and working in IT helps me to realise myself.	0.866	
	Studying IT and working in IT gives me a chance to develop myself.	0.724	

Perceived abilities	My teachers think that I'm successful in the field of IT.	0.743	0.860
	The field of IT matches with my abilities.	0.795	
	I have good programming skills.	0.830	
	For me, it is easy to engage in IT.	0.847	
	I know what working in IT is like (e.g. I have visited an IT company)	0.511	
Altruistic motivation	IT skills give me a chance to contribute to the development of Estonia.	0.716	0.877
	IT skills give me a chance to be useful for the world.	0.898	
	IT skills give me a chance to make people's lives easier.	0.911	
Social pressure	IT skills make me more popular among my friends.	0.510	0.720
	My parents direct me to pursue activities related to IT.	0.568	
	My friends pursue IT (e.g. independently, study IT or work in IT).	0.480	
	Someone in my family pursues IT (e.g. independently, study IT or work in IT).	0.425	
	My friends affect my choice to pursue IT or not.	0.658	
	I have already been in touch with IT professionally.	0.510	
Positive learning experiences from school	Informatics/computer science classes develop my IT skills.	0.703	0.801
	I get good grades in informatics/computer science classes.	0.531	
	Informatics/computer science classes have increased my interest toward IT.	0.718	
	Informatics/computer science classes are useful for me.	0.862	

An average rating of each factor on a 5-point scale is represented in Table 2. The results show that students' motivation is highest in relation to the value of future work (average rating 3.82). This factor comprised the items related to good job position and good pay in IT field and clearly shows the importance of extrinsic variables. This was followed by the factor in the second place, named importance, which put together items related to the usefulness of IT skills and to the opportunities of self-realisation and self-development (average rating 3.55). This factor comprised items related to mostly intrinsic variables. These factors were followed by altruistic motivation (average 3.39) and positive learning experiences from school (average 3.34). Lowest rated was the factor related to the interest toward IT (average 2.72). There were also several differences between the ratings of boys and girls as well as grade 9 and 12 (see Figure 9). The boys rated all factors statistically significantly higher than girls ($p<0.05$). Within the ratings of students in grades 9 and 12, there was a statistically significant difference between all factors, except for the factor of self-efficacy. Grade 12 students rated all these factors higher than students of grade 9.

Table 2. Students' average rating of factors related to motivation.

Factor	Average rating	Standard deviation
Value of future work	3.82	1.00
Importance	3.55	0.92
Altruistic motivation	3.39	1.01
Positive learning experiences from school	3.34	0.94
Self-efficacy	3.01	1.05
Positive learning experiences	2.89	1.03
Social pressure	2.87	0.72
Perceived abilities	2.86	0.75
Interest	2.72	0.75

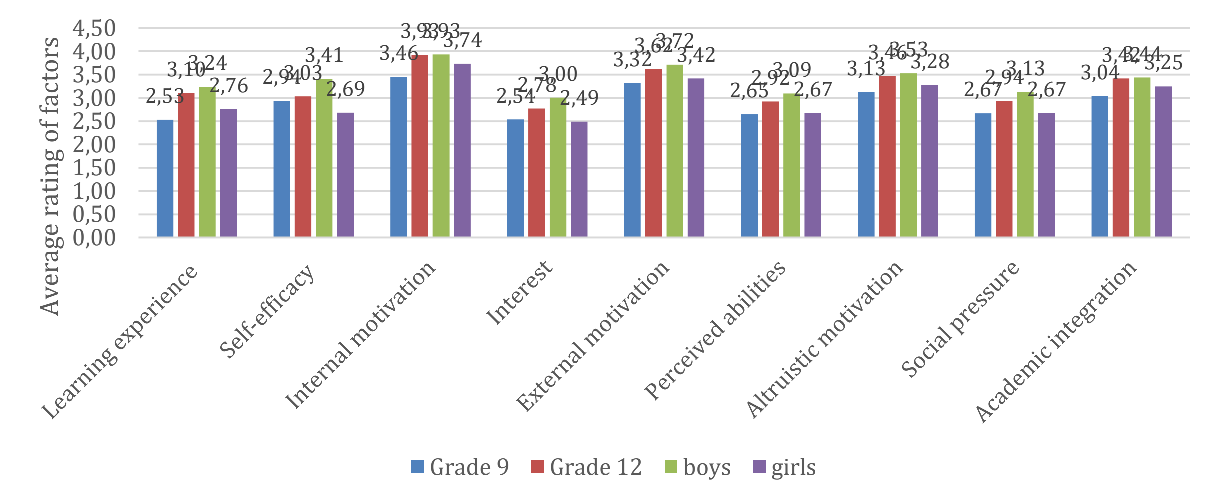

Figure 9. Ratings of boys and girls of grades 9 and 12 in relation to factors associated with motivation.

Interviews made it clear that the interest and motivation to study information technology had its roots in the childhood, where the first contact with the computer included playing computer games. One of these games was Minecraft:

“Famous game Minecraft, smartly programmed, smartly written numbers and letters.“

“Minecraft was the game when I went to my mother saying please buy this game. It develops your world of thought, I still play this game.“

In addition to games, role models such as family, relatives, acquaintance, etc. were the cause for inspiration of and maintaining the students’ motivation.

“It came on its own, well I think it’s a family thing, a relative already doing it. I had an interest toward IT 3-4 years ago already, but toward programming, last spring or summer. Mother told me that a relative had went to Tallinn Technical University and so I looked at what you could study there, one that caught my eye the most was programming.“

“My interest is very high and the interest has come from acquaintances.”

“All the interest is because of my brother, my brother already was interested in this and right now he works in the Ministry of Finance.“

Students also brought out that leading figures such as Elon Musk and Steve Jobs had been the shapers of their interest and motivation:

“The interest mostly started from Elon Musk and Steve Jobs.“

Additionally, interviews showed that not only the role models, leading figures, and computer games played in the childhood were the initiators of interest but it also included the responsibility when writing a program:

“A great thing about programming is that I know that usually all the mistakes I do, are really my own mistakes, in some other fields, um weather was bad and whatever, but no, absolutely everything you say to the computer, the computer does it, so when I finally find a mistake and correct it on my own, then I know that I gained something from it, it is something that I really-really like.“

Previously mentioned factors eliciting interest mainly included those related to child’s home. As for schools, it was brought out that hobby groups offered there were also eliciting interest toward IT:

“When I was little I went to Lego robots hobby group and we programmed them there and it was exciting, then, I don’t know, the interest has stuck with me from this. I was very little, grade 5 maybe.“

“I go to programming hobby group, we use HTML and Python there.“

Some students brought out aspects that have reduced their interest toward IT. Main aspect reducing and demotivating interest was the constant sitting in front ot the computer and its adverse health effects:

“I used to consider the option to go to a vocational school to study it but then I realised that this work is nothing but sitting in front of a computer all time, like, there’s not much going outside of the room with this work.“

„My interest is so-and-so. I like our informatics class but some years ago and right now we have some tasks on the computer and I have to spend too much time in front of a computer and then, for example, my eyes get tired really quickly and then I myself get tired.“

„If I sit in the class, then I look at all these programs and I get it that it’s hard and you have to look around on the computer a lot, it affects my health especially and it develops really quickly, there is a lot to learn.“

In addition to health, negative experiences and the complexity of some IT areas also added to the reduced interest. For example, an experience with creating web pages:

“I would say that I really enjoyed doing various olympiad tasks, competition tasks, but I didn’t like the moment when we started looking at web applications and things where the beautiful and clear system of programming started going really hazy for me so I understood that my brain does not work exactly this way.“

5.3. Seeing their future in IT

For the students to make their choice whether to bind their future with IT or not, it is preferable that they have an overview of what IT is about. Consequently, the students were asked in the interviews to explain the meaning of information technology. Four main definition themes were established:

- Information technology is everything related to the computers (including tablets, smart boards, desktop computers, phones):

“*IT is information technology, it’s everything, then, that is related in a broad definition to computers, smart phones and such and software, the development of it, then all kinds of smart applications and such, something like that.“*

“Well I would say, that it’s kind of, like everything that deals with computers, either the putting together the computers or using everything about it and all kinds of smart devices. Basically, all devices, like, for example, radios and things like that.“

- Information technology equals programming or information technology is creating programs, programming. Things related to the computer and programming were often mentioned together as one answer:

“Look, programming is part of information technology, it’s a big part of it, related to many devices, web sites, smart phones, ID-cards. It’s all connected and leads our lives.“
„Basically everything that is dealing with electronics and computers. It’s, yeah, everything that is related to computers, programming, everything that comes with them.“
“*Kind of like creating computer systems, programs, writing code. Sitting in front of a computer and, like, thinking up these codes. I’ve had this impression.“*

- Information technology as transferring information and creating:

“Well, the programmers, like, they do this, there was no information and the information now is or some program wasn’t and then the program is, it’s the same with the people who do 3D modelling. Then they, like, create it. It’s, like, creating. Creation.“
“/.../ you can find necessary information that you need to find or it could mean that you are learning it, learning to do important and necessary things for yourself over the internet.“”

- Information technology equals digitality:

“Information technology is technology that doesn’t exist in real form, only digitally. It’s not a physical thing. For example, the programs made with programming languages, engines for the programs, so you can’t just touch with your hands, so you need something that helps to use it physically. Like a controller, like a mouse that you can use to control it all.“

“So that’s everything related to computers, how they work, why they work and so on. I probably couldn’t explain it better, well yeah, everything that’s inside, that’s outside, everything that exists, so to speak, digitally-physically. That’s the information technology. Lots of thinking.“

Additionally, IT was described as means for comfort, a tool to make life easier, sitting in front of a computer, big machines, and developing software. The definition of information technology in reality encompasses more than was described, and to understand that, it should be explained to the students that IT is not only programming.

In the questionnaire, 37% of students responded that they wish to see their future in IT (to study IT or work in IT). There was a significant difference between the answers of boys and girls – 53.3% of boys and only 21.1% of girls saw their future in IT.
The students were also asked in which way would they see their future in IT. The answers have been shown in Figure 10. Mostly, the desire was to study IT in an higher education institution or to

participate in some IT-related course. There were more boys than girls who responded that they would like to work in IT immediately (p<0.05). However, this difference between the boys and girls was not as big in basic school as it was in upper secondary school.

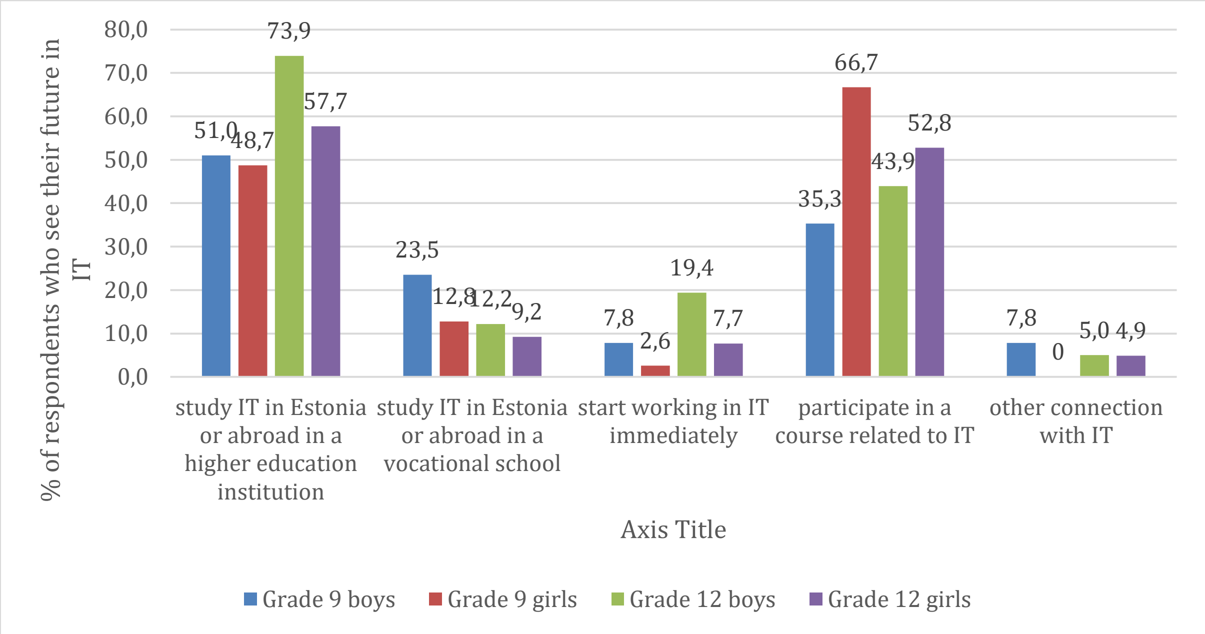

Figure 10. How would the students see their future in IT?

Students were asked in the questionnaire whether they would like to work as an IT teacher in the future. This item was rated on a 5-point scale and the average response was 1.4. This means that students do not wish to work as IT teachers in the future. However, a statistical significance was derived from the responses of boys and girls. The boys rated the item regarding working as an IT teacher in the future slightly higher (boys' average 1.6, girls' average 1.3; p<0.01). Additionally, the students rated the item about whether they want to connect IT with some other speciality in the future as their job. Average rating for this item on a 5-point scale was 2.6, and this item was also rated statistically significantly higher by the boys, compared to the girls (boys' average 3.3, girls' average 2.2; p<0.01).

The interviews showed that the choice of picking information technology in the future depended on whether students had previous interest or not. Information technology and related fields, toward which the students had a study interest in, included:
- programming,
- informatics,
- hardware: *"I have no specific thoughts but I'm thinking of information technology, computer repairs. I'm not suited with codes, more like doing something with your own hands."*,
- business information technology: *"Business information technology, there you will interact with people and it's interesting to me."*,
- robotics and electronic engineering,
- mathematics.

For this reason, the definition of information technology should be explained more to youngsters so that they could choose a desirable field within information technology.

5.4. Teaching experience of IT teachers

In the questionnaire, IT teachers were first asked about their background (see Figure 11). Most teachers responded that they have studied IT independently (76.2%) and participated in IT-related trainings (76.2%). Just 33.3% of teachers had been studying in a higher education institute to become an IT teacher, however, also 33.3% of teachers have finished IT study programme in higher education institution.

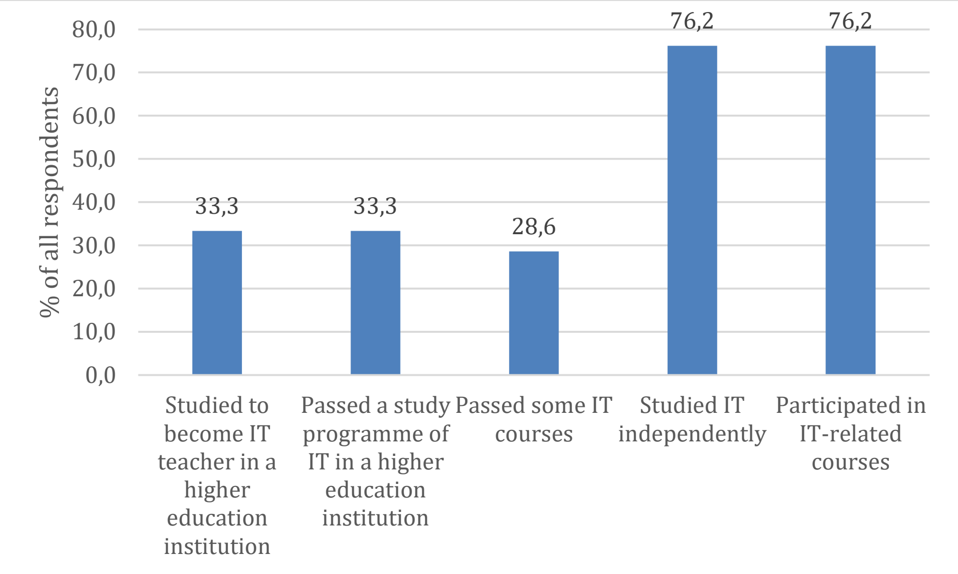

Figure 11. Background of IT teachers.

The study mostly included those teachers who had taught IT for at least ten years (45%). 20% of the respondents had been teaching 6-10 years, 30% of the respondents had been teaching 3-5 years and 5% of the respondents had been teaching 1-3 years. The work loads of teachers giving IT classes varied significantly: 25% of teachers gave 1-2 classes a week, 20% gave 3-5 classes, 30% gave 6-10 classes, and 25% gave 11-20 classes.

When asked about their future, 90% of teachers responded that they will continue teaching IT at school. 75% of teachers responded that they wish to supplement their skills in trainings and 60% responded that they want to supplement their skills independently. There was one teacher among the respondents who expressed the plans to not continue teaching IT.

5.5. Teaching IT skills at school

When visiting schools, study environment in relation to teaching IT was examined. The placement of computers in the computer class and the existence of ICT tools received particular attention. The placement of computers in the classroom helps the work of the teacher, and chairs with adjustable height are necessary in the aspect of health. Schools generally had well-supplied classrooms and tools for teaching. All study classrooms were provided with either projectors and smart boards, or just projectors. All schools had 3D printers, two schools also had virtual reality glasses. One school had i3 Lighthouse interactive floor projection.

Computer classrooms had different interior placements in schools. Two schools had the usual placement with computers on the desks as in classrooms. One teacher found this placement of the tables suitable but the other teacher did not as it was difficult to see what the students were doing. The best placement in the opinion of the teacher was when the tables were placed against the wall and some tables were pushed together. This way, the teacher had the best overview when walking around in the classroom. Computer classrooms were generally in a good condition. As it turned out from the interviews, more important than the placement in computer classrooms was the human factor. Teacher's innovative and creative solutions to make the class more interesting was something that can elicit interest in the young toward the field of information technology.
Schools also had several devices related to robotics. Different schools had different devices and they were used to integrate different subjects. For example, there was a cooperation with Tallinn University to integrate mathematics and robotics in grades 3 and 6 with the help of Edison and EV3 robotics kits.

Interviews showed that informatics is taught in schools in various ways. These include:

- informatics studies starting in the first grade;
- informatics studies for one or two years;
- programming hobby groups for all students and also separately for girls;
- as an optional subject in upper secondary school or in the field of study of science-engineering/science-information technology;
- informatics integrated into different subjects (mathematics, nature, geography).

During the interviews, the teachers highlighted that there is not enough preparation in the basic school to pick the field of study of informatics in upper secondary level. There is no separate motivation provided in basic school to pick the field of study of information technology in upper secondary school, but rather, this field is picked by those who were already interested in information technology in basic school.

92% of teachers responded in the questionnaire that IT is taught in their school as a separate subject, 68% responded that IT is integrated into other subjects (e.g. mathematics or science classes) and 60% responded that IT is taught in a hobby group. IT subject is mandatory for students in most schools as was responded by 72% of the teachers. 48% of the teachers responded that IT subject is mandatory in a certain field of study, 48% responded that IT subject is optional for everyone and 8% responded that IT subject is optional in a certain field of study.

As there is no unified IT curriculum in schools, the teachers were asked their attitude toward such a system. Most teachers (60%) had no definitive answer, 32% thought that this is mostly good or very good, and only 8% thought that this is mostly bad. In the opinion of the teachers, the negative aspects included the lack of study materials and that different students receive different preparation (inequality). Positive aspects included having an autonomy for the school, being able to consider the profile and possibilities of a school (e.g. hardware, software, teachers' skills) and as the field of IT is growing rapidly, the contents of a mandatory class must be renewed each year. Some recommendations included that in the case of a mandatory class, an e-course could be considered.

Teachers were also asked to rate several items in the questionnaire that were related to things potentially needed to support teaching IT in schools. The average ratings of teachers are displayed in Table 3. The teachers rated all items very high – on a 5-point scale, the averages for all items were above 4. Highest rated were the items saying that more IT-related study materials are needed to use in teaching, and a better system is needed to find teachers (e.g. from universities) to invite teaching IT-related courses or parts of courses at school.

Table 3. Assessments of IT teachers in terms of what is needed in schools to teach IT.

Item	Average rating	Standard deviation
More IT-related study materials are needed to use in teaching.	4.58	0.58
A better system is needed to find teachers (e.g. from universities) to invite teaching IT-related courses or parts of courses at school.	4.52	0.71
Teachers need to be provided additional IT-related continuing education.	4.46	0.72
Students need to be provided additional IT-related e-courses that could be carried out with the support of the school.	4.29	0.62
Schools need more financial support to purchase hardware and software.	4.29	0.69
A better system is needed to invite IT companies to school or to visit IT companies with class.	4.29	1.04

Teachers gave their ratings for the necessity of different IT courses they thought are needed for the students and for the IT teachers themselves. The average assessment in terms of ratings are displayed in Table 4. For most courses, the teachers rated that they are needed more for the IT teachers than for the students ($p<0.05$). However, there were two courses which ratings didn't have a statistically significant difference ($p>0.05$). These included digital services and cyber security. Cyber security also stood out for the highest rating for its necessity to both students and teachers (4.50 and 4.63 on a 5-point scale, respectively). For the students, the courses with the lowest ratings for necessity included software development (average 2.52) and software analysis and testing (average 2.54). These courses may be more specific than the others and necessary to a smaller part of the students who see their future related to IT. For the teachers, the courses with the lowest ratings for necessity also included software development (average 3.75) and software analysis and testing (average 3.75) but the necessity for 3D modelling course received ratings which were just as low (average 3.75).

Table 4. Ratings of teachers for courses needed for students and IT teachers.

Course	Needed for students, average rating (5 – needed for all students, 1 – not needed for students); standard deviation	Needed for IT teachers, average rating (5- very much needed, 1- not needed); standard deviation	Result for Wilcoxon test
Cyber security	4.63 (0.77)	4.50 (0.66)	$Z=-0.711$, $p>0.05$
Digital services	4.13 (1.08)	4.04 (0.70)	$Z=-0.354$, $p>0.05$
Multimedia	3.54 (0.83)	3.96 (0.69)	$Z=-2.055$, $p<0.05$
Programming	3.46 (1.02)	3.96 (0.75)	$Z=-1.985$, $p<0.05$
3D modelling	3.33 (0.92)	3.75 (0.79)	$Z=-1.978$, $p<0.05$
Web design	3.21 (1.02)	3.92 (0.83)	$Z=-2.796$, $p<0.01$
Robotics	3.08 (1.02)	3.83 (0.82)	$Z=-2.928$, $p<0.01$
User-centered design and prototyping	2.79 (0.83)	4.08 (0.71)	$Z=-3.923$, $p<0.01$
Software development	2.54 (0.66)	3.75 (0.90)	$Z=-3.788$, $p<0.01$
Software analysis and testing	2.54 (0.93)	3.75 (1.03)	$Z=-3.699$, $p<0.01$

In the questionnaire, the teachers were also asked about different activities at school that might raise students' interest toward IT and the frequency of these activities at school (see Table 5). All of these activities in schools were assessed as taking place rather infrequently. Most infrequent activities included the students visiting IT companies (average 2.08 on a 6-point scale), IT companies visiting schools (average 2.17), and IT-related theme days or theme weeks (average 2.17). Most frequent activities included IT-related hobby groups (e.g. programming, robotics) but their frequency was also not rated as being very high (average 3.5 on a 6-point scale). Consequently, it is the opinion of teachers that all of these activities should be more frequent at school.

Table 5. Teachers' assessment of frequencies of such activities at school that increase interest toward IT.

Activity	Average frequency (6-point scale)	Standard deviation
IT-related hobby groups (e.g. programming, robotics)	3.50	1.22
Participation in IT-related competitions	3.29	0.95
Students are introduced to IT-related courses (incl. e-courses) outside school where they can participate in	2.96	1.12
IT-related theme days or theme weeks	2.71	1.27
IT companies visiting schools	2.17	0.82
Students visiting IT companies	2.08	0.78

The teachers also rated several items about the experience of their students in relation to studying IT (see Table 6). The teachers rated the items in a manner where 1 stands for not being applicable to almost any student, and 5 stands for being applicable for almost every student. Highest rated items included those related to possibilities of studying IT at school. It seems that schools generally have necessary equipment (e.g. hardware, software) to teach IT (average rating 4.5), and the students have the possibility to study IT at school (average rating 4.08). Items that were rated rather high also included those which claim that the students have a positive experience studying IT (average rating 3.88), and that the students are interested in studying IT (average rating 3.46). On average, the teachers thought that less than half of the students want to see their future in IT (average rating 2.67).This is also similar to the responses of the students themselves (37% of the students responded that they see their future in IT).

Table 6. Teachers' assessments of items related to the experience of their students studying IT.

Item	Average rating on a 5-point scale	Standard deviation
Students have the possibility to use necessary tools for studying IT at school (e.g. hardware, software)	4.5	0.78
Students have the possibility to study IT at school	4.08	1.10
Students have a positive experience studying IT	3.88	0.68
Students are interested in studying IT	3.46	0.83
Students see their future in IT (e.g. study IT or work in IT)	2.67	0.64

In the interviews, the teachers were asked about the best practices in their school when teaching IT. The best practices generally included the existence and will of innovation. Some examples of the best practices are as follows:

- The teacher and students create content into ClassVR (virtual reality glasses), e.g. something to supplement biology or geography subjects.
- Interactive floor projection i3 Lighthouse which is in contrast with regular projector-board-type classes.
- 3D printer is used in different subjects (e.g. mathematics, technology studies). In the context of mathematics, for example, some complex geometric shapes were printed.
- Robotics tools to teach mathematics and programming. For example, playful mathematics with LEGO EV3 robots.
- Google Suite and other Google services which are used, for example, to hold e-study days to develop students' ability to study independently.
- A girls-only programming group. Girls who might not feel confident while programming together with boys can do it in a separate hobby group.
- Teaching informatics starting from grade one which either includes a hobby group for robotics, or the integration of informatics into subjects.
- Teaching informatics takes place in two groups, that is, the class is divided into two groups and group-based teaching is used. This gives the teacher a possibility to reach all students during the class.
- Learning one programming language (Python) within the first midterm of upper secondary school and another programming language (Java, C#, C) within the second midterm.
- Integrating informatics subject with English and mathematics subjects in grade 8.
- In the upper secondary level, maintaining the relationship between the teacher and the student on a colleague to colleague level where the learning process is cooperative in nature. There are some youngsters that have chosen a field of study of informatics in the upper secondary level and possess knowledge that supplement the knowledge of the teacher. This creates a situation that conforms to the contemporary concept of learning.

In summary, the common denominator for best practices of the teachers is the creative use of various technological tools during studies.

5.6. Teaching STEM skills

IT skills fall under STEM skills. Consequently, teachers were asked about the broader teaching of STEM skills at school. The results showed that STEM skills are mostly taught in separate subjects (70.4%), but there were also schools were STEM skills are taught integrating different subjects (40.7%) and some schools include optional subjects where STEM skills are integrated (29.6%). When the teachers rated the items about how STEM skills should be taught at schools, the results showed that in most cases, integration of subjects in order to develop STEM skills was favoured. The following items were most highly rated: STEM skills should be integrated into optional courses at school (average rating 4.15 on a 5-point scale), and STEM skills should be taught while integrating different subjects (average rating 4.13). The item stating that STEM skills should be developed in different subjects was rated lower (average rating 2.96).

In the current study, we considered four types of skills falling under STEM skills: inquiry skills, computational thinking skills, mathematical problem solving skills and IT skills. Teachers considered STEM skills to be necessary for students (average rating 4.13 on a 5-point scale). Teachers also rated on a 5-point scale the extent of how school turns its attention to developing these skills (see Table 7). The results showed that in the opinion of teachers, the development of inquiry skills receives the most attention (average rating 3.79), the importance of which is also highlighted in the national curriculum. Following this, teachers think that attention is given to the development of mathematical problem solving skills (average rating 3.38), which is clearly related to the subject of mathematics. STEM skills that are more related to the computer science or informatics classes (computational thinking skills, IT skills) receive less attention in teachers' opinion (average rating 2.96 and 3.08, respectively). Still, these ratings are not very low, rather falling under „not important and not unimportant".

Table 7. Teachers' rating of the extent of attention turned toward the development of different STEM skills.

STEM skill	Average rating on a 5-point scale	Standard deviation
Inquiry skills – skills used to explore patterns related to processes taking place in the world, formulating hypotheses/questions, and confirming them with experiments or observations.	3.79	0.78
Mathematical problem solving skills – skills used to find a problem within context, modelling it mathematically, applying it, and interpreting the results.	3.38	0.97
IT skills – skills to create something (e.g. programming), software testing skills, database management skills, hardware management skills, etc.	3.08	0.88
Computational thinking skills – skills to formulate and solve problems which are presented in the manner readable by an information process agent (e.g. a computer, machine, robot).	2.96	0.86

6. Recommendations

Several recommendations can be highlighted as a result of this study to increase general education school students' interest toward studying IT, give them a more adequate overview of what IT is about and help them make the decision whether IT is something they see their future in or not.

- The results of this study showed that boys' first contact with programming takes place in a more independent manner, compared to girls. Consequently, **girls should be more directed toward programming and IT at school**. One school included a positive example of girls' programming group, which is a good step toward the direction mentioned. Directing girls toward IT should already take place in the first and second stages of study, where, according to previous research, the difference between boys' and girls' interest toward the digital world starts to appear (*Tuleviku tegija teekond startup ökosüsteemi*, 2018).
- Several students participating in the current study brought out gaming and independent experiments as eliciting interest toward IT. Consequently, **to increase interest toward IT in school, playful methods should be used**. There is a previous study that reached the same conclusion: playful methods and granting students more independence to try what the students want to try lead to an increasing interest toward IT (*Tuleviku tegija teekond startup ökosüsteemi*, 2018).
- The results of this study showed that students visiting IT companies themselves elicits more interest toward IT, compared to IT companies speaking at school. Consequently, **IT companies should invite students to visit them in order to introduce the field of IT. This**

should already take place in basic school as according to the results of the current study, this is the time period when students are more easily influenced, compared to the upper secondary school. Additionally, previous research has shown that interest toward IT starts at a young age (e.g. Kori et al., 2014). If the students have a chance to see the daily life and working environment of a company, it elicits more interest, compared to the representative of the company visiting the school. As for the latter, students participating in the study thought that it also may increase the interest if the speaker was interesting and famous and would talk in an interesting manner.

- While examining students' motivation, it was found that the interest toward IT was rated lowest. These ratings were lower in the case of grade 9 students, compared to grade 12 students, and lower for the girls, compared to the boys. **Consequently, a greater deal of attention should be directed to students of basic school and to girls to raise their interest toward the field of IT**. Teachers' responses in the interviews also indicated that teaching IT receives more attention in upper secondary school, compared to basic school.
- It is the opinion of IT teachers that schools lack both IT-related study materials and IT teachers. Therefore, **more study materials (including e-courses) should be created to teach IT and there is a need for a system in schools to find IT teachers**. Teaching IT could be divided into courses at school so that certain visiting teachers could attend schools to hold courses or parts of them.
- Teachers participating in the study felt the need for self-development in the field of IT. Therefore, **more IT-related training should be offered to teachers**. Courses related to cyber security were considered particularly important to offer to both teachers and students.
- **Activities raising the interest toward IT should be held more frequently in schools**. In addition to IT companies visiting schools, teachers think that schools should hold more IT-related theme days or weeks or a one IT-day in a theme week. IT theme day may be conducted in an open learning environment context, not necessarily in a computer class. **The informatics class could also be held in an open space where the focus is placed on the teamwork** and a flexible placement of furniture and space gives an opportunity for a more dynamic way of learning. During the interviews it was found that students don't want to sit in front of a computer throughout the day. Therefore, **active rest periods should be integrated into computer studies** like is done in IT companies (e.g. stretching pauses, gymnastics, yoga).
- A perception was prevalent among the students participating in the study that IT is everything related to the computers or programming. There are other areas encompassed by the term, however, and to change this way of thinking, **other technological tools could be used in study process in addition to a computer (e.g. 3D printer, ClassVR, robots, interactive floor projection)**.
- Different students in one school and even in one class have a very different range of IT skills and interest. Consequently, **schools should offer IT or programming groups for both the beginners and for the more advanced**. The beginners need confidence when learning programming and the advanced need to retain motivation and interest.
- **To leave/transfer some informatics studies into the final stage of study in the basic school** to give students a more unified knowledge base while transferring from basic school to upper secondary school.
- The teachers participating in the study highlighted several creative methods that have increased students' interest toward studying IT. Based on these experiences, **a flipped classroom methodology could be used in informatics classes to shift the focus on cooperation between the students as well as between the teacher and students**. This is

particularly important in an upper secondary level where the students have skills of various levels and some may possess skills better than these of the teacher. This type of cooperation would be a two-sided learning where knowledge and experience could be shared.

- **Schools could integrate different subjects into informatics classes** (e.g. Estonian language and informatics, mathematics and informatics, or even physical education with mathematics and informatics). Based on the experiences of schools participating in the study, these types of integrations have increased the interest of students toward IT. Additionally, this kind of integration may give a better overview for the students in terms of how IT is related to other fields.
- **Career days could be held to get a better picture of information technology, or someone could be asked to visit the school who can introduce the learning opportunities and areas of information technology**. This is necessary for the students to gain a unified understanding that information technology does not just equal programming.
- The results of this study show that STEM skills that receive most attention in school include the development of inquiry skills and mathematical thinking skills; the skills related to technology do not receive such attention. Consequently, **schools could shift focus to developing students' IT skills and computational thinking skills**.

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