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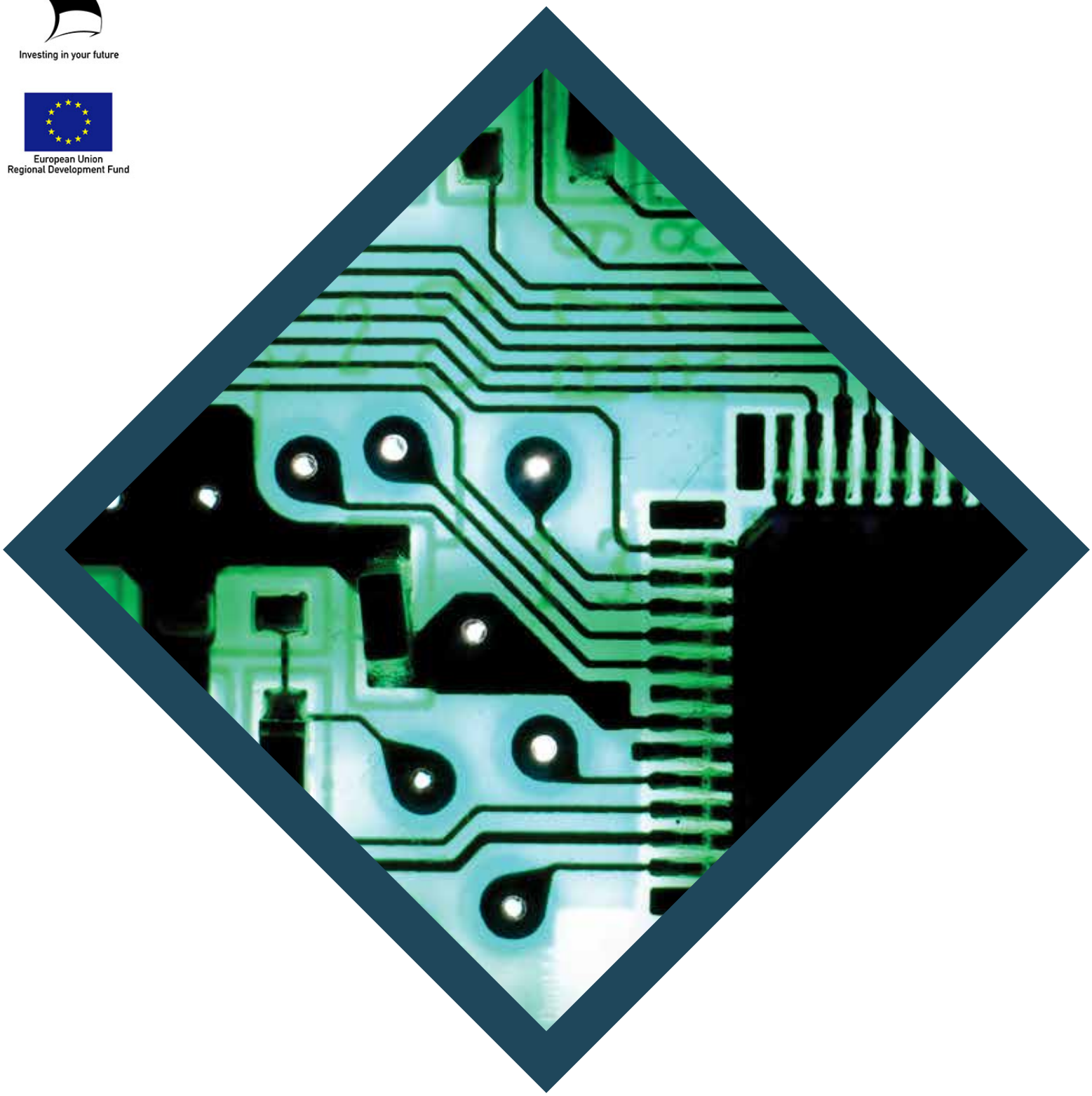

• University of Tartu • Tallinn University of Technology • Estonian Information Technology College •
• Estonian Association of Information Technology and Telecommunications •

What happens to IT education in Estonia?

Who will study IT? How will it be studied? Who will drop out? What can be done?

Framework

Tartu 2015

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Executive summary

During the past decade, the demand for people with IT skills and knowledge has increased in Estonia. For some time, there has been a shortage of programmers and several other types of IT workers, and the problem is not restricted to Estonia (Hüsing et al., 2013). To ensure the sustainability of the IT field, it is important to revise the present situation of IT education and identify areas that could be improved. The current study focused on three aspects: IT students' source of interest in the IT field, motivation to continue their higher education IT studies and motivation to graduate.

Sparking an interest in IT in young people can already start at the general education level, where no obligatory informatics subjects or courses are prescribed by the Estonian national curricula. Still, several elective IT subjects are taught in Estonian schools (Estonian Education Information System, 2015). In general, three fields of specialization can be distinguished between in the IT education provided by Estonian schools: field of computer science (related to programming, robotics, etc.), field of regular user (texts, data, tables, presentations, etc.), and field of other subjects (related to the use of relevant programs and tools).

Since there are no state-level tests or exams in IT subjects and no central learning materials either in Estonia, IT education in schools and its outcomes are not regulated by any specific requirements. According to the Estonian Education Information System (Estonian Education Information System, 2015), computer studies/informatics is taught in 397 basic schools, but in reality, similar subjects are taught in even more schools. There is even more diversity in upper secondary schools – less than half of the elective courses on computer studies/informatics taught in upper secondary schools stem from the list provided by the Estonian national curriculum (Estonian Education Information System, 2015). Several fields of study in upper secondary schools are also connected with the IT field, e.g., information technology or STEM-oriented information technology. There might be greater focus on informatics in the STEM-oriented field, but even this is not known for certain. Also, some subjects are taught in Estonian upper secondary schools which, by their names, do not reveal the extent of their connection with IT: Technology, Multimedia, etc.

There is great diversity in subjects related to programming, as well – a dozen different programming languages are taught in Estonian schools (Puniste, 2015). Learning programming at the general education level is, however, highly beneficial for future IT students: according to the current study, it gives IT students an advantage in the first study year compared with their peers with no previous programming experience. In addition to the content of the informatics subject, there is also a shortage of qualified informatics teachers, since many teachers who are currently teaching this subject in Estonia have not studied informatics in a higher education institution, and it is even more rare that they have studied to become informatics teachers (Pedaste and Mäeots, 2011). Here, in-service training and retraining for informatics teachers

plays an important role, as teachers usually try to immediately implement in their work what they have picked up in the training (Kallas, 2015).

To sum up, moderate coordination of and collaboration in teaching IT at the general education level could prove highly useful.

At the level of higher education, the sample of our study in 2013 consisted of all students who had enrolled in the informatics and information technology curriculum cluster at the University of Tartu, Tallinn University of Technology and Estonian Information Technology College. In 2014, some data was also collected from the relevant curricula at Tallinn University. Unfortunately, the admissions figures of just two years already manifest the tendency of a decreasing number of new students.

We found that the primary factor influencing students' choice of curriculum was their interest in IT. When asked about the defining moment which had sparked an interest in IT in the students, the experience of some kind of hands-on activity was the most popular answer. The experience involved, for instance, getting their own computer, solving computer-related problems, creating websites, etc. This kind of experience could therefore be offered to children early in life in order for them to become interested in IT.

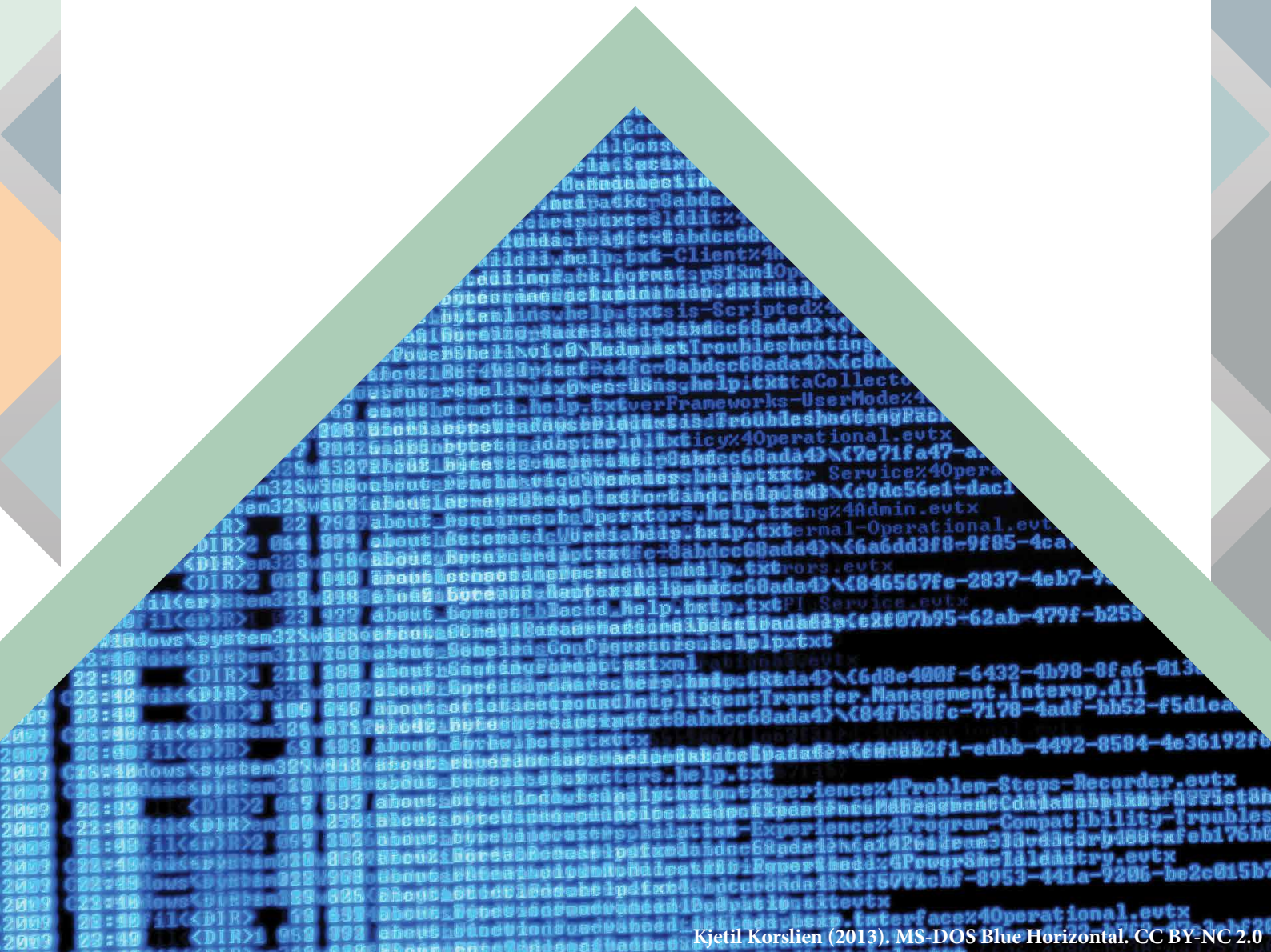
In the first study year, relatively few IT students were working in the IT field; by the end of the second year, however, every fifth IT student had found an IT-related job. According to the students, the primary reason for going to work during studying was their financial situation, followed by gaining work experience and finding an interesting and suitable job. To improve their financial situation, IT students in Estonia also have the chance of getting a scholarship, which is higher than in other fields. However, only a small proportion of them actually receive the scholarship: 34.4% of the students said they were paid the scholarship, and the average sum was 160 euros. The students themselves felt that in order to sufficiently commit to their studies and graduate in the standard period of study, the scholarship should be larger – approximately 261 euros in the first study year and 341 euros in the second year.

In the IT field, there is a risk of relatively poorly prepared young people dropping out of their studies and finding a job which does not require higher qualifications. Thus, part of their potential remains unused in the IT field. In Europe, the average dropout rate in IT related curricula is 19% (Hüsing et al., 2013), whereas in Estonia, as many as 32% of IT students dropped out already in the first study year. Our study revealed that the result of the mathematics state exam was an important indicator in predicting dropout – students with lower scores were also more likely to drop out of their IT studies. One of the reasons could be that the first study year contains some math-related subjects which may be too difficult for those with poorer previous knowledge of the subject. We also detected some other differences between IT students who dropped out and their peers who continued their studies. Those who kept studying rated the following aspects higher than those who dropped out: their interest in IT, accordance of the curriculum and studies with their expectations, probability of graduation and probability of starting work in the IT field after graduation.

In order to more thoroughly investigate the reasons for dropping out, phone interviews were carried out with 35 former students in the informatics or computer engineering curricula of the

University of Tartu (69% of all the students in these curricula who dropped out during the first study year). The interviews revealed that the primary reason why the interviewees had dropped out was that IT had no longer appealed to them from a personal point of view or that IT had not been their first choice when entering university. At the same time, some of the students simply changed the curriculum, but still stayed in the IT field. Some of the former students had started working in the first study year and could therefore not spend enough time on their studies anymore. Also, the students who had already been working before university pointed out that they would have liked to continue studying IT in evening studies, but the university did not offer this option. As for going back to university, 14% of the dropouts intended to do so in the future.

Based on the answers of the students and results of this study, several recommendations can be made to pupils, university students, parents, general education schools, higher education institutions, IT companies and policy makers to ensure the sustainability of the IT field. The recommendations intended for these target groups are presented in this framework.



Recommendations

Based on the results of this study, secondary analysis of data available about Estonia, expert opinions and analysis of relevant scientific literature, we can make recommendations to different target groups. The purpose of the recommendations is to foster the sustainable development of the IT field and help people make informed career choices. Recommendations to different target groups are often based on the same data; however, the nature of the recommendations may be different. It is also considered important by the team who conducted the study that each target group could focus on the recommendations made specifically to them. Therefore, the recommendations are divided into seven groups: recommendations to pupils, higher education students, parents, IT companies, higher education institutions, general education schools, and policy makers.

Recommendations to pupils

Primary school pupils

1. **Get involved in IT at an early age.** 36% of the IT students pointed out that the defining moment which sparked their interest in IT was when they had the chance to do something exciting on the computer (Kori et al., 2014). 23% said that the defining moment occurred already in childhood – in the primary school or even earlier. Present-day primary school pupils already have an advantage compared with the students who filled in the questionnaire, because they have much more contact with computers and smartphones.

For me, the defining moment was "when our family bought a computer, because whenever there was a problem, I would have to solve it myself..."

"Close contact with computers every day and the growing wish to learn more about their inside."

2. **Try doing something on the computer yourself.** The IT students pointed out that they became interested in IT when they had the chance to do something creative on the computer (Kori et al., 2014). In the primary school, Scratch (http://scratch.mit.edu/), for instance, is a good tool for developing digital creativity. Scratch is an environment for visual programming meant for children over the age of 8 (Maloney et al., 2010). The advantage of Scratch compared to textual programming languages is that it allows the user to see and move concrete objects (Maloney et al., 2010). In addition to Scratch, ScratchJr (http://www.scratchjr.org/) has been created for younger children (aged 5–7) and the Logo WeDo robotics set for children from 5 years of age. In addition to trying to do things on your own, it is also useful to participate in hobby groups.

"In the primary school, I tried creating my own website..."

"Probably the first program that I wrote..."

3. Participate in an IT hobby group. We recommend finding out which IT hobby groups there are in your school, other schools or online and participate in these, if possible. Such hobby groups give you opportunities to try different things and may get you interested in IT (Kori et al., 2014). Another advantage of hobby groups is the availability of a teacher or supervisor who can help you and give you immediate feedback.

4. Develop your digital skills. Developing your digital skills is important, as it helps you to climb up the "ladder of online opportunities" and benefit more from using the computer (Stald et al., 2014). For developing your digital skills, it is important to think about what you are using the Internet for and what you are doing there (Stald et al., 2014). The necessity of developing your digital skills is also underscored by the fact that starting from 2014, the Estonian national curriculum includes the digital competency, i.e. the ability to effectively and safely use digital tools for learning and in everyday life as one of the general competencies (National Curriculum for Upper Secondary Schools, 2011). But remember that you need to protect your personal data while using the Internet!

Basic school and upper secondary school pupils

1. **Before entering higher education, be sure about what you are going to study.** We recommend going through the materials available on the Web, participating in universities' open days, visiting universities to see what the students are doing and going through web pages providing career advice. This helps you to make an informed decision about your future speciality. Right now, every third high school graduate in Estonia admits that the decision about what to study tends to be rather incidental (Mägi and Nestor, 2012). The current study revealed that only a small proportion of students were well informed about their curriculum at the beginning of their studies (Kori et al., 2014). The decision about what to study should be based on your inner vocation and not on stereotypes, which tend to suggest that a person working in the IT field is a pale-skinned thin male who is extremely intelligent (even geeky), technology and computer oriented and low on social skills (Cheryan et al., 2013; Sainz et al., 2014). It is also a good idea to consult a career advisor when planning your future.

2. **Try doing something on the computer yourself.** A hands-on experience in working with a computer can get young people interested in IT – according to 36% of the IT students, this was the defining moment which sparked their interest in IT (Kori et al., 2014).

"I started programming myself."

"...when I messed up, I had to fix it myself so my parents wouldn't get upset."

Playing computer games, for instance, is an activity that can arouse young people's interest in IT. This was seen as the source of their interest by 6% of the IT students (Kori et al., 2014). In addition to attracting children to IT, playing computer games is also associated with getting them into creating computer games themselves.

"I have played loads of computer games since I was little, which is what got me fascinated with computers in the first place."

"In order to do better in computer games (cheat), I used to change the game files, created maps for a game (strategy game map), which required logic and a bit of programming..."

3. **Choose your speciality based on your inner interest, not on potential financial gains.** Our study revealed that the majority of students enrolling in IT curricula did not consider the financial aspect (scholarship, future salary) as a particularly weighty reason for starting and continuing their IT studies (Kori et al., 2015b). Only a very small proportion of student candidates regarded the financial aspect as the reason for applying – high salaries in the IT field were mentioned by only 3.3% and bigger scholarships by 0.3% (Kori et al., 2015b). When the IT student candidates were asked to estimate the extent to which six predefined factors influenced them to apply, job opportunities and salaries were ranked as low as fifth. Nevertheless, most of them felt that not getting a scholarship would more likely influence them toward dropping out and that getting a scholarship would more likely have a positive effect on their academic results. Other studies, too, have revealed that students enrolled in computer related curricula tend to assign less importance to their future salaries than students in other specialities (Alexander et al., 2011). At the same time, some studies have also shown that receiving financial support increases the probability of students finishing their studies (Chen, 2012; Stratton et al., 2008).

4. **If you think that IT suits you, consider continuing your studies in the IT field – there is a great demand for IT workers, and the profession brings many benefits.** In the IT job market, there are plenty of vacancies in both Estonia and the rest of Europe. By 2020, depending on the sector's growth scenario, an estimated 2661–4456 additional workers are needed in the Estonian IT sector in occupations requiring IT qualifications. IT skills are also necessary in many other fields, which is why it can be said with relative certainty that studying IT ensures a job in the future. According to polling firm Praxis, the number of IT specialists outside of the IT sector will increase by approximately 4000 by the year 2020 in Estonia (Jürgenson et al., 2013). Right now, additional workforce is particularly sought after in software development: for instance, there is great demand for developers, testers, analysts, architects, and managers (Jürgenson et al., 2013). Also, the IT field showed great potential during the economic crisis. At the beginning of 2009, for instance, after the financial sector had been devastated by the results of the fourth quarter, IBM surprised the world's stock markets by announcing its strong financial results, and this particular example is no exception (Estonian Development Fund, 2009). Therefore, the IT field is more likely to be sustainable in the future, as well. In 2000–2012, programming productivity increased in Estonia and in 2000–2010, telecommunication productivity was also on the rise (Statistics Estonia, 2014).
In addition, the The Estonian StartIT website lists some of the benefits that a degree in IT can bring along: a good salary, interesting job, solid future, flexible working time, creative environment and the opportunity to work in a prestigious field with a variety of cool and interesting jobs and people (http://startit.ee/miks-it/).

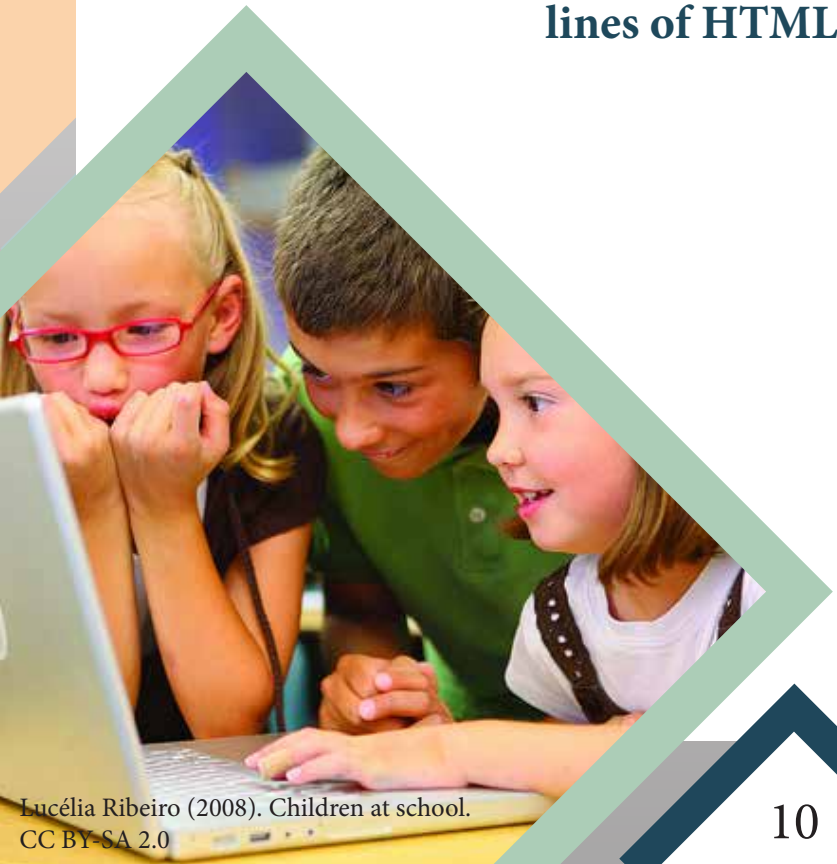
"The IT sector as a whole has withstood the crisis better than the rest of economy."

"In the IT job market, there are vacancies in both Estonia and the rest of Europe. By 2020, depending on the sector's growth scenario, an estimated 2661–4456 additional workers are needed in the Estonian ICT sector in occupations requiring ICT qualifications."

5. **Already in school, take the opportunity to learn programming and mathematics.** The current study shows that IT students who have previous experience in programming do better in their higher education studies than those with no past programming experience (Kori et al., 2015a). So far, we have found that previous programming experience gives students an advantage in the first and second semester – those who have learned programming before have a higher average grade and consider their studies to be easier than those who first came into contact with programming in their higher education studies (Kori et al., 2015a). Other studies have also shown that the more programming languages a student has learned, the better he or she performs in tests and exams (Hagan and Markham, 2000). Learning mathematics in school also contributes to success in later IT studies, where mathematics becomes a necessity; the current study revealed that students who scored lower in the mathematics state exam were more likely to drop out in their first study year (Kori et al., 2015c). Also, 9% of all IT students referred to the computer class in school as the source of their interest in IT.

"The defining moment was probably in the 10th grade, when we had a compulsory computer course in school where we wrote some code."

"When we were first taken behind the scenes of the Web in basic school and I got to write my first lines of HTML and CSS."



6. **You can also learn in hobby groups – know your options.** A survey carried out by the Estonian Association of Information Technology and Telecommunications (ITL) showed that 52% of the pupils in the 9th–12th grades had no idea if their school had a technology hobby group or not (ITL, 2014). The best cure for not knowing is finding out yourself. If you cannot learn IT in your own school, you can look for other possibilities: for instance, there are plenty of materials on the Web (keywords: MOOC and Codecademy), and various trainings and courses are provided by higher education institutions, as well.

7. **Enrol in higher education immediately after finishing high school.** Studies have revealed that those who enter higher education right after graduating from high school are less likely to drop out (Stratton et al., 2008). This is particularly important for men, since older men are at a greater risk of dropping out of their higher education studies than younger men (Stratton et al., 2008). As for women, age does not appear to have a significant influence on the probability of dropping out (Stratton et al., 2008).

8. **Do not be afraid of moving to another place to study what you want, but make an informed decision.** Check all higher education institutions for their IT curricula and then make an informed decision based on which curriculum suits you most. Living at home may be cheaper, but moving to another city to study could still prove more useful. However, different studies have produced results that are somewhat contradictory: for instance, Belloc et al. (2011) found that students who were living and studying in the same city were more likely to drop out or change their speciality within the same institution. Our study, however, revealed an opposite trend. We distinguished between three groups: (1) the last school from which the student graduated is located in the same city in which the student is currently studying; (2) the last school from which the student graduated is located in the same county in which the student is currently studying; and (3) the last school from which the student graduated is located in a different county than the one in which the student is currently studying. The results show a statistically significant difference between students who dropped out and students who continued their studies – a large proportion of those who dropped out had finished their previous school in another county. However, we do not know the reasons for this tendency. Therefore, we can only recommend considering your options as well as costs of living in another city and, if these are not an obstacle, making your decision based on the content of the studies.

9. **Women should not be afraid of studying IT.** Women manage at least as well as men in the IT field and are therefore more than welcome. A survey on the popularity of specialities carried out among 9th–12th-grade pupils by the Estonian Association of Information Technology and Telecommunications (ITL) revealed that whereas 20% of boys were interested in studying IT, only 2% of girls expressed the same interest (ITL, 2014). Our study detected no differences between men's and women's academic results (men's average grade in the first semester was 3.39 and women's 3.38). Also, it has been found that women are more likely than men to finish their studies (Belloc et al., 2011). Overall, there are significantly fewer women than men in the IT field – in Estonia, 78% of IT occupations are filled by men (Jürgenson et al., 2013). Female IT students said that more women should be active in the IT field, since women could come up with different solutions compared with men. For instance, in programming, women could pay attention to other kinds of problems compared with men and therefore program differently (Ziugand, 2014). Koppi et al. (2010) found that women in IT occupations were more concerned with

communicating with people, whereas men were focused on the technical aspect. Overall, there are 22% of women working in the IT field in Estonia, and the proportion of women is larger in those IT occupations which involve more communication. For instance, the proportion of women is 43% among consultants and trainers; 34% among digital media specialists; 33% among project and service managers; 32% among technicians and user support and sales specialists; 31% among analysts and architects; and 28% among testers (Jürgenson et al., 2013). At the same time, there are particularly few women among programmers – only 8% (Jürgenson et al., 2013).

"Very happy. I mean I don't feel like a female student. I blend in. I feel good and comfortable in the company of boys."

"IT companies do not in any way prefer men or hire you because you're a woman. They just value your skills."

"It has actually been emphasised quite a lot at career information days that all IT companies want to hire more women."

10. **When using a computer, also think about your health.** You should not spend too much time on the computer, as it involves various health risks, such as eye fatigue, headache, back pain and hand pain (Lai and Uri, 2008). Excessive use of the computer can also lead to insufficient sleep, which makes it harder to concentrate in school, eating irregularly and even addiction (Lai and Uri, 2008).

11. **When using a computer, also think about protecting your private data.** In recent years, risks involved in using the computer have increased. When comparing the years 2010 and 2013, more and more young people have started using a smartphone and/or tablet in addition to the desktop or laptop computer (Stald, 2014). Always protect your data when using a computer or smart device. You can find several sites dedicated to smart devices security on the Web, e.g., http://www.kidsmart.org.uk/, http://www.theguardian.com/technology/2013/sep/16/10-ways-keep-personal-data-safe.

Recommendations to higher education students

1. **Be consistent and finish your IT studies.** Only half of the workers in the Estonian IT sector have a higher education degree (Jürgenson et al., 2013); in the rest of the world, however, the proportion of workers with higher education degrees has increased in the IT sector (Sum et al., 2007). Having a higher education degree will give you better chances in your career. We recommend not stretching your studies over too long a period of time: the faster students graduate, the greater their productivity both in the public sector and the private sector (Kivinen and Nurmi, 2014). There are many factors that could influence you towards dropping out (see Kori et al., 2015c), but knowing the risks and how to avoid them (see the present recommendations) can help you be consistent and get your degree.

Having a higher education degree will give you better chances in your career.

2. **IT is not just programming.** Take a look at the different subfields of the IT field, because IT is not just programming – even someone who is not that into programming or even afraid of it can find a topic of interest among the many IT subfields, and people with IT knowledge and skills are also needed in other fields. It has been found that fear of mathematics can influence a person's career choice (Chipman et al., 1992). Students should understand that the first study year is relatively similar in different curricula, containing many basic subjects – you should not decide to drop out based on your first-year experience. In Estonia, it is also possible to choose between different curricula, and higher education institutions offer flexible solutions to students.

"ICT is an industry that horizontally passes through the other sectors. This means that a good specialist can find a job anywhere, be it music, fashion or timber industry."

3. **Serious commitment to IT studies is essential for a beginner.** Studies have shown that in the case of students with no previous experience in IT, pushing themselves and really making an effort allows them to achieve equal results compared to their peers. Our study revealed that spending more time on studying led to better academic results (Niitsoo et al., 2014). Good academic results are important: students who have poor grades and collect fewer credits in their higher education studies are more likely to drop out (Belloc et al., 2011; Stratton et al., 2008; Chen, 2012). Those who are used to studying hard and had better grades in high school have been found to be more likely to finish their higher education studies as well (Belloc et al., 2011).

4. **Even an experienced IT specialist must study hard at the higher education level.** In the case of students with prior experience in the IT field, studying hard is important for minimizing the risk of dropping out. Our study revealed that spending more time on studying led to better academic results (Niitsoo et al., 2014).

5. **When working during your studies, keep your workload as low as possible.** It is common that young people want to go to work while studying – a survey carried out in Estonia showed that 61% of students were working during their studies (Beerkens et al., 2011). Already when finishing high school, 45% of young people plan to go to work during their higher education studies and 47% are not sure; only 8% of high school graduates have no intention of working during their studies (Mägi and Nestor, 2012). As for IT students earning extra money (42%) and practice in the field (28%) are the main reasons for going to work (Kori et al., 2014). Similar reasons are pointed out by high school graduates – 74% plan to earn extra money and 16% want to gain some work experience (Mägi and Nestor, 2012). At the same time, studies have shown that the more hours per week students work, the higher the probability of dropping out (Polidano and Zakirova, 2011). With a high workload, students have less time for studying, which affects their academic performance (Triventi, 2014). Therefore, if students need to work during their studies, we recommend finding a job in the IT field and keeping the workload low – this way, it is possible to practise the knowledge obtained in university and still have enough time for studying.

6. **Balance your studies and family obligations.** It is natural that students who have families of their own need to find time for their family obligations (raising children, earning income) in addition to studying. However, family obligations and studies need to be in good balance to prevent the risk of dropping out. It has been found that married men are more likely to temporarily suspend their studies than single men. At the same time, married men are less likely to withdraw permanently from their studies than single men (Stratton et al., 2008). Married women are also at a higher risk of temporarily suspending their studies than single women; however, no difference has been found between temporary suspension and permanent withdrawal in the case of women (Stratton et al., 2008).

Cumminsr (2011). Student laptop. Wikipedia CC BY-SA 3.0

Similar tendencies have been detected in the case of students who have children – women with young children are at a higher risk of permanently dropping out, whereas men with young children are more likely to finish their studies (Stratton et al., 2008).

7. **Communicate with your fellow students to blend in the IT community.** It has been found that students who communicate more with their fellow students and lecturers are less likely to drop out (Chen, 2012). Dropping out is also influenced by how much energy students put into studying, how much time they spend on campus and how actively they participate in student organizations (Duque, 2014). Our study, too, revealed that the learning environment factor, i.e. students' relationship with their peers and lecturers and participation in the IT community motivated them to continue their IT studies. Therefore, it is important to have a good relationship with fellow students and lecturers to be motivated to keep studying.

8. **Consider enrolling in postgraduate studies after receiving your Bachelor's degree.** It has been found that students who plan to enrol in postgraduate studies are less likely to drop out of their undergraduate studies (Chen, 2012).

9. **Try to avoid stress.** It has been proven that if students are happy with their studies, they are more likely to graduate (Duque et al., 2013; Duque, 2014), whereas stress and exhaustion decrease the probability of graduation (Duque et al., 2013; Duque, 2014). You can read about stress here: http://www.helpguide.org/articles/stress/stress-symptoms-causes-and-effects.htm.

Recommendations to parents

When your child is in kindergarten or primary school

1. **Already at an early age, children should have the opportunity to do some hands-on activities on the computer.** Children develop their interest in computers relatively early and it largely depends on whether they are given the chance to play and practise on their own computer. Based on our survey, 36% of IT students became interested in IT when they had the chance to do something on the computer by themselves or even take the computer to pieces (Kori et al., 2014). However, it should be kept in mind that information on the Internet is not presented so that it develops children, and, therefore, children need to be taught skills of evaluating the validity of information.

"Getting my own computer was the defining moment, the beginning of my gradually growing fascination."

"Probably getting my own computer, which also involved taking care of it."

2. **Visual programming is a good way to start.** For instance, primary school children could try using Scratch (http://scratch.mit.edu/). Scratch is an environment for visual programming meant for children over the age of 8 (Maloney et al., 2010). Textual programming languages may be too abstract and complicated for children, whereas Scratch has the advantage of having concrete objects that users can see and move around (Maloney et al., 2010). IT students also pointed out that the source of their interest in IT was trying programming. In addition to visual programming, programming games can also be helpful, e.g., Lightbot http://code.org/learn. Graphical programming can also be done with robotics packages designed for young children (www.robootika.ee/jrfll).

"Discovering programming, which gave a new meaning to my already existing interest in creating things." "My first experience with programming, which was very positive."

3. **Help your child pick a hobby group.** IT hobby groups may get children interested in learning IT. We also recommend checking which hobby groups are offered by other schools – these may be more suitable for your child. A survey carried out by the Estonian Association of Information Technology and Telecommunications (ITL) showed that 52% of 9th–12th-grade pupils had no idea if their school had a technology hobby group or not (ITL, 2014). Although you need to pay for many hobby groups, it is always a good idea to go and see what people are doing there and if it is worth paying the fee.

4. **Parents should be more aware of what is going on in the digital world.** In kindergarten, the number of children using smart devices increases; however, parents do not usually live in the same digital world as their children. Parents should keep an eye on what their children are doing in the digital world and learn about the potential threats. Also, it is necessary to recognize when the child has become addicted to the computer. We also recommend participating in trainings related to these topics, if possible.

When your child is in basic school or upper secondary school

1. **The role of parents is to actively ask for possibilities of learning IT for their children.** School is meant to support children's development together with their parents, including providing suitable IT education (as a separate subject or integrated into other subjects). In our study, only 9% of IT students pointed out that the source of their interest in IT was an IT class or course in school (Kori et al., 2014); this proportion could be bigger if schools provided better IT education. Also, parents could work in closer cooperation with schools, for instance, helping schools write projects for buying hardware, finding a good IT teacher, etc.

"When I started attending a Java course in school."

"Informatics classes and competitions in school."

2. **Digital competency is a general competency which all people should develop.** Starting from 2014, the Estonian national curriculum lists digital competency among other general competencies which schools should develop in pupils. Digital competency is described as the ability to effectively and safely use digital tools for learning and in everyday life (National Curriculum for Upper Secondary Schools, 2011). Digital competency is also important for adults, which is why we recommend discussing together with your child how to support each other in developing this competency. Often, IT tools provide us with possibilities beyond our everyday activities. For instance, there are applications which allow us to monitor the quality of our sleep or physical activity (Sleep Time, Sleep Cycle, Sleepbot, Runtastic, Sports Tracker, Steps Mania, etc.). The better digital competencies you have, the more opportunities you have to make your life easier and more comfortable.

3. **Set an example in using IT possibilities in your everyday life.** Parents could educate themselves more in the IT field and be role models for their children – according to our study, parents and their IT related activities set an example for their children in developing an interest in IT (Kori et al., 2014). A European study of information processing skills among adults also revealed that Estonians used IT less than the average outside of work (OECD, 2013). We encourage parents to organize IT hobby groups in schools, share their knowledge with the children and set an example.

"Probably because of contact with programmers at my dad's workplace, and he himself writes smaller-scale programs, too."

"My mother has been a great role model for me. She has studied a similar speciality. She suggested that I should find out more about business information technology. And after that I knew this was going to be what I wanted to do with my life."

"... Dad recommended studying IT, because it would most likely guarantee a good future..."

4. **Freedom must not become freedom from responsibility: you should check what your child is doing on the computer.** Excessive use of the computer also involves various risks. Kalmus, Blinka and Olafson (2013) found that if parents were involved in their children's use of the computer and set certain limitations, the children did not spend too much time online. There are also applications which can be used for monitoring children's online activities. For applications for Windows, check https://account.microsoft.com/family/about; for advice on smart devices, see, for instance, Mobicip (http://www.mobicip.com/) and Screen Time Labs (https://screentimelabs.com/). Still, monitoring the child's activities and using technical solutions may not be as effective as discussing the issues directly with the child (Kalmus et al., 2013). In addition to excessive use of the computer, attention should also be paid to privacy protection. Studies have shown that risks related to using the Internet have increased when comparing the years 2010 and 2013, as more and more young people have started using a smartphone and/or tablet in addition to the desktop or laptop computer (Stald, 2013). The biggest risks that pupils have pointed out are the following: communicating with someone they do not know in real life; seeing sexual images; and websites on hate, advocacy for anorexia, drug use, self-injury, etc. EU Kids Online (Stald et al., 2014) recommends the following activities to parents in order to support their children's use of the computer: 1) actively communicate with children and provide them with suitable online activities; 2) give children advice on how to use the Internet securely; 3) set certain rules as to what the child is allowed to do online; and 4) use filters and tools for monitoring the child's online activities.

5. **Too much of a good thing is no longer good – using the computer involves various health risks which should be conscientiously prevented.** Using the computer may get children interested in IT, but we also recommend making sure that your children do not spend too much time on the computer, since it involves various health risks, such as eye fatigue, headache, back pain and hand pain (Lai and Uri, 2008). Excessive use of the computer can also lead to insufficient sleep, which makes it harder to concentrate in school, eating irregularly and even computer addiction (Lai and Uri, 2008). In addition to what has been mentioned above, excessive use of the computer is related to becoming overweight, cyberbullying, losing money in Internet games or frauds, and harmful information available on the Internet, which may affect a child's values and development (Kalmus et al., 2014). For recommendations on using the computer, see, for instance,
http://www3.imperial.ac.uk/OCCHEALTH/guidanceandadvice/computerhealth/computerhealthgeneralguidance. There are also programs that help limit the time of using the computer and

force you to take breaks, e.g., Workrave http://www.workrave.org/. It is also important that you set a good example to children when it comes to your own computer use.

6. **Do not worry too much about your child breaking the computer.** IT students pointed out that "breaking" the computer was what got them interested in learning IT in the first place.

"In the 4th grade, I got my own computer, and when I messed up, I had to fix it myself so my parents wouldn't get upset."

7. **Let the children educate themselves in the IT field.** If you feel that you know less about something than your children, let your children teach you. This is a good way to value your children's skills, and it can really increase their self-belief and motivation. If children receive positive feedback, they feel better about the activity and will be more eager to continue doing it later as well (Harackiewicz, 1979; Butler, 1987). It has been found that engaging parents in the learning process contributes to the child's learning and learning outcomes (Mo and Singh, 2008). One of such activities could be programming together.

8. **Guide your child towards developing critical thinking when it comes to computers.** Children need to develop their critical thinking, because not everything they encounter on the Internet is true. It has been found that not only children but older people, too, have problems with judging the results of a web search as well as the reliability of the source (Walraven et al., 2008).

When your child is in a higher education institution

1. **Value higher education.** If parents value higher education and have a higher education degree themselves, their children are also more likely to graduate from a higher education institution and not drop out of their studies (Stratton et al., 2008).

2. **Students need financial support to focus on their studies.** A large proportion (42%) of IT students would go to work during studying to earn money (Kori et al., 2014). At the same time, studies have shown that when students go to work, they have less time for studying and are at a greater risk of dropping out (Polidano and Zakirova, 2011; Triventi, 2014). On the other hand, interviews with Estonian IT students have revealed that they have a great desire to become independent and earn their own (extra) money (Linn, 2014). Therefore, your children who are already students should be supported in a way which would not undermine their wish to be independent (for instance, covering all costs related to their studies may not always be the best solution).

MCPearson (2013). Work in the computer lab. Wikimedia Commons CC BY-SA 3.0

Recommendations to general education schools

IT studies and popularization in school

1. **High quality IT education should be available to pupils in all general education schools.** In Estonia, the national curriculum does not provide obligatory computer/informatics subjects – these competencies may also be taught within other subjects (Fraillon et al., 2013). Nevertheless, many schools have opted for separate subjects/courses. We recommend thinking about how computer/informatics education is organized in your school and which support you would need to ensure that your pupils have access to good quality IT education.

2. **Schools should provide their pupils with the opportunity to learn programming.** In order for student candidates to be better prepared for IT studies, programming should be taught in schools. Prior experience in programming gives IT students an advantage in the first semester – the average grade of the students who have learned programming before entering higher education is higher in the first and second semester and they find their studies to be easier than their peers who have no previous programming experience (Kori et al., 2015a).

3. **Talented pupils who are interested in programming can be offered relevant courses outside of their schools.** To get talented pupils even more into IT, they should be encouraged to participate in programming courses in various other education institutions. For instance, 25% of the 12th-grade pupils who successfully passed the online course Let's Make a Computer Game provided by the University of Tartu Institute of Computer Science in the academic years 2012/2013 and 2013/2014 came to study informatics at the University of Tartu; 13% of those who dropped out of the course did the same.

4. **The school career advisor should also introduce IT specialities to pupils.** You can find information about IT specialities at http://startit.ee/ (in Estonian). Also, higher education institutions offer schools various opportunities for getting to know IT specialities, and pupils can participate in Job Shadow Days (http://www.ja.ee/toovarjupaev). Statistics on school visits by the Estonian Association of Information Technology and Telecommunications (ITL) show that school (62%) as well as Facebook and career advisors (40%) are the sources from which pupils would like to receive information about IT specialities (ITL, 2014). Pupils who perform well in STEM subjects prefer the media (television and radio) more (49%) compared with other pupils. As to other information channels, their preferences are similar to the average. Compared with other pupils, 12th-grade pupils prefer Facebook (52%) more as the source of information but would less often turn to career advisors (41%).

5. **Accept school visits and invite people from IT companies to teach lessons in school.** IT companies have shown interest in going to schools and introducing their fields of activity and job opportunities. This kind of introductions may increase young people's interest in studying IT

– 9% of the IT students pointed out that they became interested in IT thanks to someone being a role model for them or recommending the IT field (Kori et al., 2014). Also, you can invite people who have finished your school to come back and introduce their jobs.

6. **The school should support and take part in IT popularization activities, such as IT competitions.** Since schools cannot teach informatics in depth, alternative motivators may prove important and useful: prizes at competitions, challenges of solving different problems, curiosity, humour, etc. This also means that ICT competitions should be carefully planned so that they are interesting for pupils. For instance, organizers could animate the events with examples from real life, anecdotes, well planned tricks, questions aimed at arousing curiosity, etc. This will create a culture of the event's reputation being so good that the previous participants recommend it to new people, and, at the same time, there is a chance of self-realization and winning prizes (Bell et al., 2011).

Versatile IT studies

7. **To attract more girls to IT education, programming should be more integrated with other subjects.** Fletcher and Lu (2009) have argued that as learning programming takes time, it should be started early and offered to all pupils. In order to increase everyone's motivation, guided discovery should be preferred to step-by-step instruction (Repenning, 2012) – this is especially effective in increasing girls' motivation. At the same time, programming should be taught according to the age group, as this can influence the success of the pupils' future learning. Our study revealed that experience in programming gave IT students an advantage in the first semester – the average grade of the students who had learned programming before entering higher education was higher in the first and second semester and they found their studies to be easier than their peers who had no previous programming experience (Kori et al., 2015a). Other studies have also shown that the more programming languages a student has learned, the better his or her academic performance (Hagan and Markham, 2000). It is recommended, however, that in younger grades, the focus should be less on the principles of programming and more on storytelling and social aspects (Wolz et al., 2011). In teaching programming, more emphasis should be put on active learning, project based learning and group work. Applying the possibilities of robotics could be an option here (Wu et al., 2008).

8. **Teaching IT can also support improving pupils' performance in mathematics.** Berkaliev et al. (2014) have shown that using computers contributes to success in mathematics and that better-performing pupils are more eager to take advantage of computer programs (e.g., Mathematica, Maple, MATLAB, Wolfram Alpha). According to Takači et al. (2015), using GeoGebra for investigating functions and drawing graphs helps learners get better results compared to those who do not use the program.

Importance of the teacher

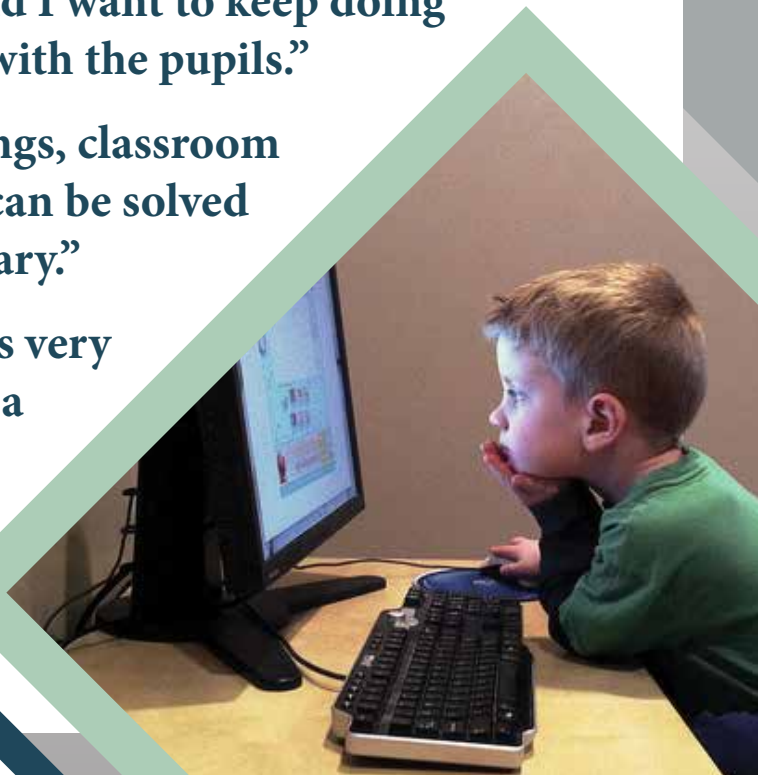
9. **Teachers should regularly and actively participate in IT trainings for teachers.** In order for teachers to have the necessary skills and courage to teach programming, they should take part in trainings which also contain face-to-face sessions. Such trainings provide teachers with both technical and didactical preparation, offering them, among other things, the chance to meet specialists active in the IT field. Data obtained from different IT courses show that programming courses give teachers more self-confidence to start teaching programming. This was confirmed by 96% of the participants in the Programming in School Computer Club (Scratch) course and 85% of the participants in the Programming in School Computer Club (Python) course; 85% of those who completed the trainings have started teaching programming in schools (Kallas, 2015). Also, to support teachers' participation in IT trainings, school leaders and the wider community should recognize the participation and using IT tools to diversify the learning process.

10. **We recommend that teachers use more IT tools in other classes as well.** A study carried out in 2012 showed that Estonian teachers believed that 7% of the Estonian teachers were not using IT tools, whereas the pupils estimated that 49% of the Estonian teachers were not using IT tools (Prei, 2013). While 14% of Estonian teachers estimated that they were using IT tools in almost all the lessons in 2010, the proportion of teachers who believed so had risen to 28% by 2012 (Prei, 2013). Teachers hold the opinion that using technology increases students' motivation and interest and makes teaching faster and easier. Pupils consider studying more interesting, more pleasant and the materials more understandable thanks to technology (Prei, 2013). In addition, a study conducted in the European Union revealed that compared with the year 2006, schools have now twice as many computers per 100 students (European Commission, 2013). Therefore, all school lessons should have the opportunity of using IT tools, and schools should foster integrating different subjects and e-learning days. To support the use of IT tools, an educational technologist is needed in school.

"Programming is fascinating and I want to keep doing it and share my knowledge with the pupils."

"In addition to distance trainings, classroom trainings, where various issues can be solved right away, are also necessary."

"The visit to the IT company was very interesting and definitely gave a good overview of how to apply programming."



Paul Mayne (2011). "His" computer.
CC BY-NC-SA 2.0

11. **In order for teachers to start teaching programming, native language teaching materials should be introduced, which could be used by both pupils and teachers.** The necessary teaching materials should be in various formats and include instructional videos, self-check questions and horizon-broadening materials. 85% of the pupils who participated in the online course About Programming rated the necessity of self-check questions as high as 6 or 7 on a 7-point scale; the usefulness of videos was rated the same by 75% of pupils and influence of horizon-broadening materials by 71%.

"Scratch instructions are mostly very good for independent work."

"Programming is, in fact, a broader topic than just Scratch. I can teach Scratch and feel relatively comfortable doing it – although I must admit that I also have many weak spots there. Of course, they can be eliminated with the help of the teaching materials."

Health requirements, freeware and cloud technologies

12. **Health protection requirements must be followed in the computer lab.** In Estonia, the rules for safely conducting IT classes are prescribed by legislation: https://www.riigiteataja.ee/akt/27096.

13. **Freeware and cloud technologies should be used more.** You should think about using freeware operation systems and programs – this type of software is free of charge, the licenses are freely available for all computers, the programs can be shared legally, and pupils can use the same software in their home computers. A lot of free software is available that does not depend on the operation system, allowing free updates and long-term use (see http://cc.com.au/files/Free-Software-for-Schools.pdf). Also, cloud technologies can be used to save and share files or work together (e.g., Google Drive, Dropbox).

Recommendations to higher education institutions

Organizing learning

1. **Offering more flexible forms of study and being more profession oriented may contribute to greater interest by student candidates.** Our data show that the admissions competition is significantly tighter in the Estonian Information Technology College than in the University of Tartu and Tallinn University of Technology. The possible reasons for this (e.g., flexibility of study, a need for professional higher education and academic higher education, importance of possibilities for continuing training in formal education) require further clarification but are undoubtedly important for developing the curricula and admissions according to the expectations of the target group. At the same time, higher education institutions should also still have the balancing role between the expectations of the student candidates and development of curricula which are in accordance with the competencies needed in the future.

2. **In order to increase the proportion of female students, offering more interdisciplinary and more flexible study possibilities should be considered.** The results of the current study show that women account for approximately 25% of students enrolling in IT related curricula throughout the years. At the same time, there are certain curricula where the proportion of women is significantly larger – for instance, 44% of the students who enrolled in the Business Information Technology curriculum at Tallinn University of Technology in 2014 were women. Also, there were 58% of women among the 638 participants in the open access online course About Programming taught at the University of Tartu in 2015. Therefore, it can be recommended that in order to bring more female students into the IT field, more interdisciplinary and flexible forms of study should be created (learning IT related to other subjects).

"Maybe a whole new module could be created or some subjects added that focus on more social fields or occupations. For example, more on testing or analysts or project managers. Right now, there are really many serious math or programming subjects. I think that adding such subjects could bring in more women."

Other countries have also noticed that female students are more interested in interdisciplinary curricula. For example, the Duisburg-Essen University in Germany offers a curriculum titled "Applied Cognitive and Science and Interactive Media", or "Komedia" in short. This curriculum combines computer science, psychology and business administration (see https://www.uni-due.de/komedia/). Students show great interest in the curriculum, and about 60% of the students are female (in other IT related curricula, about 25% are female). After finishing their bachelor's studies in "Komedia", students can choose if they want to continue their studies at the master's level in IT or psychology – more and more female students choose IT.

3. **Expanding interdisciplinarity is necessary.** IT is linked with many other fields, and people who have preparation in both IT and some other field are in great demand in the labour market. More than half of those who completed the open access online course About Programming (over 400 people) taught in 2015 said that if they had to choose a new speciality, they would probably opt for something related to programming (Tõnisson, 2015). Therefore, when developing curricula and organizing studies, it would be reasonable to take into account the needs of this specific target group and design possibilities for them to connect their previously acquired speciality with the IT field. Also, it should be considered how to offer flexible solutions for parallel IT studies to students who are still studying another speciality (or, analogously, allow IT students to study another speciality in parallel). This would help broaden the application of IT competencies in interdisciplinary work. The organizational prerequisite for this kind of flexibility would probably be reducing the amount of classroom work and increasing the amount of online work (so that it would be possible to study several specialities or while going to work).

"Since I'm interested in both IT and economics, I found that business information technology was a speciality which included both."

4. **In IT studies, attention should also be paid to general skills: communication skills, learning skills, self-expression skills, etc.** Communication is important during studies, as well. Whereas in general, employers tend to be happy with the specific IT skills of the IT graduates in Estonia, there is more room for improvement in communication skills, learning skills, oral and written self-expression skills, basic entrepreneurship skills, etc. (Väljur, 2013). However, separate specific subjects may not be the best solution for developing such skills. International studies have shown that good relationships between students, between students and lecturers, as well as between lecturers are important in higher education studies and especially for preventing students from dropping out (Bennett, 2003). Informal communication with peers, extra-curricular activities and communication with the university and its administrative personnel supports the students and makes them feel as part of the community. Those kinds of activities can therefore help retain students (Tinto, 1973). So, solutions are needed that provide different people with a reasonable amount of possibilities for communication in both real life and web-based communities (including within courses, but also outside of courses).

5. **The curriculum and organization of studies should be negotiated more with different parties.** Throughout two study years, students' ratings of the accordance of their curriculum and studies (lecturers and study methods) with their expectations have been stable, but not particularly high (between 3.4 and 3.8 on a 5-point scale). Thus, there should be more discussion between students and lecturers in order to find out what could be changed. As a result, it may either turn out that students' expectations are justified and contribute to the development of the curriculum, lecturers and study methods, or students will better understand the plans and intentions of the lecturers. Students would also greatly benefit from a career advice service. In addition, preparing lecturers pedagogically may help them better support their students.

6. **Previous experience in programming is important.** Interviews with dropouts revealed that programming did not appeal to many of them. At the same time, they pointed out that an introductory year and gaining some previous experience in the IT field would serve as a solution for increasing students' awareness of the curriculum. 44.3% of the IT students who participated in the current study had learned programming before entering higher education. Prior experience in programming gave them an advantage in their studies. Their weighted average grade in the first and second semester was higher and they found their studies to be easier than their peers with no experience in programming. Here, higher education institutions could offer optional courses to pupils (primarily mathematics and programming) which help increase their awareness of the field. At the same time, such results may also demonstrate a need for more diverse and interdisciplinary curricula.

7. **Think about how to support the students who are working.** In the first study year, relatively few students go to work, but starting from the second study year, the proportion of working students begins to increase significantly. This should also be taken into account in the development of curricula and organization of studies. What could be considered here is, for instance, more practical courses in collaboration with employers, but also tasks that support making a conscientious connection between studies and work. Also, more flexible forms of study should be offered starting from the second study year which would allow students to combine work and studies. Our data received from students who are working show that working in the IT field tends to increase students' interest in IT.

"Make working part of the studies already at the bachelor's level."

"Offer the possibility of full-time studies also to those who cannot be present every day (if lectures are obligatory then the videos could be watched at home, attending lectures could be replaced by exercises, etc.)"

Admission to the university

8. **Often, admission competitions only appear to be tight.** Informing potential student candidates should be actively continued. Regardless of the admissions competition, practically all candidates are accepted in IT studies in Estonia if they meet the minimum admissions requirements set by the higher education institution (mostly results of the state exams, which do not directly reflect the person's professional capabilities, e.g., programming capabilities). Although there has actually been an admissions competition in recent years, fewer students have ended up enrolling in the studies than the number of existing student places in the curricula. That is why recruitment activities must be actively continued, and it should be further investigated what could bring more people into the IT field. Even if attracting enough student candidates might be an even bigger problem in other fields, it should still be noted that it is also an issue in the IT field.

9. **Slightly older people, who have finished high school some time ago, should be considered as potential new students, as well.** A large proportion of IT students (especially in the University of Tartu and Tallinn University of Technology) have entered the higher education institution almost immediately after graduating from high school. Considering the demographic situation and the job market, more attention than before should be paid to offering study possibilities to older people, as well. In doing so, full-time undergraduate or postgraduate programmes might not be the only solution. Our study shows that of those who start their IT studies, 21.4% already have a degree in some other field. The experience of those people should be considered when developing curricula. In addition, full-time bachelor's and master's studies may not be the only option, and offering one-year master's programmes should be considered.

Collaboration

10. **Collaborate with IT companies in organizing practice.** 28% of the students said at the beginning of their studies that the reason for going to work during studying was getting some practice (Kori et al., 2014). Therefore, it is important for universities and IT companies to find suitable and flexible solutions for offering practice places that meet the expectations of both the university and IT companies. If the practice is well organized, the amount of practice can be increased in the curriculum. Also, the aim of the practice should be made clear. Three different forms of practice can be differentiated between: practice in IT companies (working in an IT company), practice as a course in the university (includes practice in an IT company), and practical exercises (in one or more courses in the university).

11. **The roles and meanings of different academic degrees and studies should be agreed.** In the IT field, there is vocational education, applied higher education, bachelor's studies, master's studies, and doctoral studies – the roles and meanings of these are not quite clear. Students, IT companies, higher education institutions, etc., can understand them differently, as well. This could lead to a situation where the same things are expected from applied higher education and bachelor's studies. Such duplication is not reasonable. In addition to the general aims, the content of and balance between theory and practice is important, as well.

12. **Help to spark an interest in IT in young people.** The primary reason for applying to IT curricula is interest in the field. Therefore, it would be reasonable for higher education institutions to concentrate, in their admissions work and in collaboration with schools, on activities that attract young people to the IT field. An interesting fact to consider is that in Estonia, for example, the decision to study IT is made as late as after finishing high school by a significant proportion of future IT students (35% in 2013 and 22% in 2014).

13. **Schools need help in offering IT education (programming, in particular).** Many schools are not in a position to offer high quality IT education which would allow pupils to conscientiously and successfully continue studying IT at the higher education level. That is why it is necessary that higher education institutions take on a more serious role in supporting IT education in collaboration with general education schools and vocational schools (for instance, lecturers in higher education institutions would help teach or prepare courses, develop online courses suitable for schools or organize IT competitions). Similar help and collaboration is needed in training informatics teachers (including offering retraining).

14. **The curriculum and studies should be explained to the student candidates in more detail.** The comparison of students who dropped out and those who continued their studies shows that even before starting their studies, potential new students should be informed more about the curriculum and studies. A large proportion of those who drop out in the first study year have probably chosen a wrong curriculum or wrong place. For instance, they are much less interested in IT than their peers who continue their studies, and they also rate the accordance of the curriculum and studies (lecturers and study methods) with their expectations significantly lower than those who keep studying.

15. **The role of master's studies needs to be explained more to students.** During the second study year (beginning of the 4th semester), more than half of the IT students still do not know whether they want to enrol in master's studies. About one third of them plan to do so, whereas 13% have no such intention. Therefore, already during the first and second study year, more attention should be paid to explaining the role of master's studies and, through this, supporting students early enough in planning their careers.

16. **Students have great expectations regarding scholarships, but the impact is unclear.** The students' answers reveal that their expectations regarding the size of the scholarships are much higher than the scholarships that are currently paid to them. At the same time, the students' expectations had grown significantly by the second study year. The effect of the size of the scholarship (for instance, on academic results or dropout rates) requires further study.

"Increasing/generalizing the scholarship regardless of academic results" would contribute to graduating.

Recommendations to IT companies

Valuing a higher education degree

1. **If you want to get real specialists from higher education institutions instead of just workers with lower qualifications, do not attract students too soon to positions with a high workload.** A large proportion (42%) of IT students would go to work during their studies to earn money (Kori et al., 2014), but this entails a great risk of dropping out (Polidano and Zakirova, 2011; Triventi, 2014). At the same time, some of the students (28%) would also go to work to get more practice during their studies (Kori et al., 2014). It has been found that working more than 24 hours a week greatly increases the probability of students dropping out of their studies (Beerkens et al., 2011). That is why it would be useful to try and create positions with a low workload and flexible schedule for students. At the same time, while employers are probably right claiming that a higher education degree does not show a person's real skills (Jürgenson et al., 2013), the employers should perhaps also think about positions which require higher qualifications – and university may just be the place where to receive those qualifications.

2. **It is important for students that employers value higher education and show the career opportunities it can bring.** Studies have shown that if employers have a negative attitude towards obtaining a higher education degree, working students tend to be at a higher risk of dropping out of their studies (Taylor et al., 2012). In the rest of the world, as opposed to Estonia, it is often hard to find a job in the IT field without a higher education degree. In the US, for instance, the importance of higher education has grown and employees with a higher education degree have better salaries (Sum et al., 2007).

Cooperation with higher education institutions

3. **Collaboration between universities and IT companies must definitely continue and become more systematic.** It is becoming more and more common that IT companies are involved in the development of IT curricula and visiting lecturers who are working as IT specialists bring in new knowledge of the current trends in the IT field (Väljur, 2013; Vestberg, 2013). IT companies are aware of the current and future needs of the job market and can recommend which specific qualifications are especially in demand in the case of IT students (Väljur, 2013). Visits to IT companies should continue as well, a recommendation also underscored in the feedback questionnaire handed out after IT teacher trainings in Estonia – the teachers saw visits to IT companies as an integral part of teacher training (feedback questionnaire on teacher trainings by the University of Tartu Institute of Computer Science). Teachers who filled in the programming course questionnaire also viewed visits to IT companies as important – 80% of the teachers were interested or very interested in such visits (Puniste, 2015). Thanks to teachers who are more aware and more motivated, pupils' awareness of the

possibilities offered by the IT field could increase, as well. This is also confirmed by a survey of ICT popularity commissioned by the Estonian Association of Information Technology and Telecommunications (ITL) – according to the survey, school serves as the source of information about IT specialities for nearly 50% of the pupils (ITL, 2014).

"I assume that if there were working groups/practice groups that would offer actual programs or services to companies that would be willing to pay. For instance, a small company would ask for a user interface program and a student or small group could write it for them."

4. **IT companies should consider creating additional practical training positions for students.** 28% of IT students said at the beginning of their studies that they would go to work during their studies to get some practice (Kori et al., 2014). That is why it is important that higher education institutions and IT companies cooperate to find suitable flexible solutions for offering practical training that corresponds to what is taught in higher education institutions. Interviews with employers (Jürgenson et al., 2013) have revealed that offering practical training positions is also a good opportunity for IT companies to find good workers while they are still studying. Students have different reasons for going to work during their studies: to acquire some work experience, become more competitive in the job market, acquire some general skills that are not taught in university, improve their insecure financial situation, earn some extra money, good job offers, and organization of studies which allows them to go to work (Linn, 2014). Taking these reasons into account helps to find the best solution.

"Obligatory practical training in a company should be included in the curriculum."

"It should be agreed in collaboration with companies where and starting from which study level students can do their practical training."

Popularizing IT

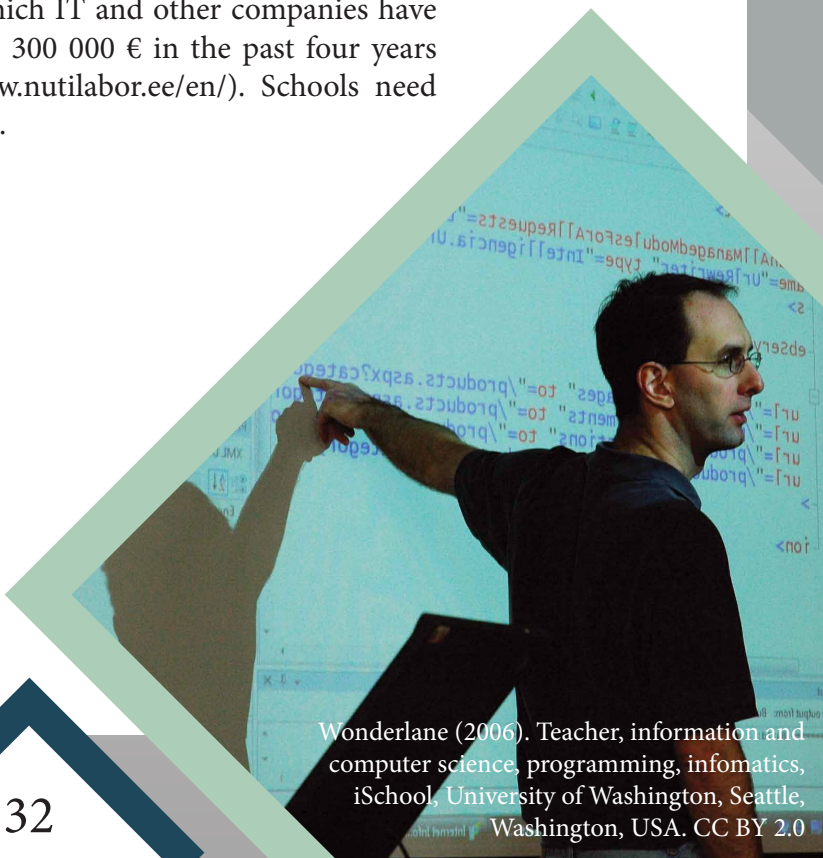
5. **The Estonian Association of Information Technology and Telecommunications (ITL) together with IT companies should definitely continue visiting schools to further increase young people's awareness of IT education and job opportunities.** According to nearly 62% of the respondents of the survey conducted by ITL, school – whether a computer class, IT hobby group or school visit – was the best place to provide information. The necessity of visits to schools is also supported by the fact that more than half (53%) of the respondents of the survey found that there was still too little information about IT specialities (ITL, 2014). Probably owing to insufficient information, natural and exact sciences (including IT) were the first choice of only

14% of high school graduates when they had to decide what to study next (Mägi and Nestor, 2012). Visits to schools should be offered already to younger students and changed from the current format to more of a "hands-on" experience. Our study showed that the interest in IT of those who enrolled in higher education studies in that field mostly stemmed from their first experience with IT tools (e.g., their first computer, website or program).

The defining moment was "intense promotion during high school and getting to know the founder of Taxify".

6. **There is an actual need for a documentary about the IT industry.** This is also confirmed by the programming course questionnaire carried out within a bachelor's thesis at the University of Tartu – nearly 70% of the teachers who filled in the questionnaire found it would be an interesting idea (Puniste, 2015). A documentary would bring the study and career opportunities available in the IT sector closer to pupils and would make them more aware of the diversity of occupations within the ICT field. A survey conducted by ITL revealed that programmer was the most widely known ICT occupation among pupils, mentioned by 28% of the respondents. Furthermore, nearly a third of the pupils could not answer this question – an alarming fact which, among other things, may be caused by pupils' insufficient awareness of the possibilities offered by the IT sector (ITL, 2014).

7. **IT companies should contribute even more to IT hobby groups.** 60% of the respondents of our study chose their future speciality in basic school or upper secondary school. Therefore, school and the possibilities it offers play the main role in pupils' choice of career. Statistics show that less than 7% of the pupils in Estonian general education schools are involved in hobby groups in the fields of IT or natural science (Mägi and Nestor, 2012). The reason behind the low involvement is lack of relevant hobby groups. The lack of IT hobby groups, in turn, is mainly caused by the size of the seed capital. The constantly evolving IT field needs new technologies (computers, smart devices, robotics platforms, 3D modelling devices, etc.), and keeping up with the latest developments requires substantial financial resources. At present, IT hobby groups in Estonia are, in addition to the state, also supported by the SmartLab programme of the Look@World Foundation, through which IT and other companies have funded IT hobby education with more than 300 000 € in the past four years (http://www.vaatamaailma.ee/en/, http://www.nutilabor.ee/en/). Schools need and are truly interested in such hobby groups.



Wonderlane (2006). Teacher, information and computer science, programming, infomatics, iSchool, University of Washington, Seattle, Washington, USA. CC BY 2.0

Recommendations to policy makers

Policy makers have the power to create suitable conditions for other target groups (e.g., schools, higher education institutions, parents) to be able to implement the recommendations made to them. Therefore, based on our study, we have produced recommendations that can be taken into account when making decisions regarding the development of the IT field either on the national, local or school level. Below, we present our recommendations to policy makers, created on the basis of data collected in our study and recommendations made to other target groups, and aimed at fostering the development of the IT field. The recommendations have been divided into four categories: content, tools, additional possibilities, and support.

Content development

1. **IT education in schools needs revising.** In Estonia, very different content – and using very different methods – is taught within computer/informatics subjects in schools. In general, three directions can be distinguished between: direction for regular computer users, computer science (programming), and linking IT with other subjects. At the same time, a need for developing the digital competency and transferable skills (for instance, not everyone needs to be taught programming, but the regular user direction and linking IT with other subjects should be available to everyone) has been highlighted in the Estonian lifelong learning strategy and pointed out as important on the international level. IT education in schools should also proceed from these principles. However, schools in Estonia often do not use the same subject syllabi provided by the national curriculum. One of the possible reasons for this is teachers' insecurity when it comes to teaching IT. Therefore, means for developing teachers' competencies need to be devised (free or low-priced trainings for teachers, learning in learning communities, etc.).

2. **External assessment should also focus on assessing transferable skills.** Learning IT fosters and working in the IT field, in turn, requires several transferable skills, such as communication skills, problem-solving skills or computational thinking skills. In order for schools to start putting more value on such skills, these skills need to be clearly assessed on the national level, e.g., in the mathematics state exam and various school exams (transferable skills can be assessed related to each subject). In addition, computational thinking skills, which are currently not part of the national curriculum, should be added there in the future.

3. **The list of professional competencies of IT workers need revising.** If what higher education institutions are teaching differs from what employers need, it should be agreed on what higher education institutions should teach. In 2014, the professional competencies were revised in Estonia, but the changes are not yet reflected in the curricula.

Ensuring tools

4. **IT tools need to be available to everyone.** In order to get pupils interested in IT in school, they need to be provided with tools which make it possible: teaching materials that support pupils' independent activities, IT tools, etc. Using free software and cloud services could be helpful here, as these are freely available to everyone. At the same time, teacher training is needed in order to provide teachers with skills (including methods) for using these tools. Pupils should be handed more responsibility for designing, completing and assessing their tasks (as is also expected according to the Estonian lifelong learning strategy).

5. **The existing IT tools should be used more for learning.** Pupils often have smart devices which could be extensively and purposefully used in almost every class and even during breaks. This requires free Internet access in the school building. It can increase pupils' involvement in hands-on activities, which is why the policies and rules of different schools should be revised and resources intended for the development of IT infrastructure should be mainly channelled into the development of free access Internet and purchase of smart devices (for those with limited possibilities). Also, parents need support (trainings, informational gatherings) to increase their awareness of how their children use smart devices and which potential threats there are.

Creating additional possibilities

6. **Enthusiasts need possibilities for specialization.** To support pupils who are particularly enthusiastic about IT, hobby groups and possibilities for additional learning in every school, higher education institutions or led by various organizations and groups need to be funded. Support is also required in creating web-based courses.

7. **Flexible, interdisciplinary forms of study are needed.** The IT field is becoming more intertwined with different walks of life, which is why specialists who are enrolled in several specialities or studying IT in parallel to their work in another field are in great demand. Therefore, more flexibility and cooperation between different fields is required in higher education studies.

Ensuring support

8. **Career coordinators or advisors have an important role in schools.** They are the ones who help pupils become more aware of what they want and make smarter choices, which should decrease the likelihood of dropping out of their future higher education studies already in the first study year or moving from one curriculum to another. This way, young people will find a quicker way to studying what fascinates them the most and inspires them to make a greater effort in contributing to their country's development. Career coordinators should also be more aware of work in the IT field; visiting IT companies is a good opportunity for increasing their awareness.

9. **Combining studies and work needs clearer regulation.** It is not reasonable trying to combine full-time studies and full-time work, but working to a reasonable extent during studies is beneficial to students. Therefore, a favourable environment needs to be established which would support creating short-term and part-time jobs for students. In the context of IT studies, it would be best if the jobs supported students' studies and the knowledge acquired during studies could, in turn, be immediately applied at work.

10. **Raising awareness of the IT field and popularization of IT requires decisive action.** Whereas in many other fields, good results have been achieved, for instance, through obligatory subjects in schools, students often have an unclear picture of the IT field. This could also be one of the reasons why a large proportion of IT students drop out of their studies as early as in the first study year. Therefore, more resources need to be channelled into activities contributing to increased awareness and popularization of the IT field.

11. **Students need possibilities for becoming financially independent without having to work too much during their studies**. Students want to become independent, but the current study loan system in Estonia does not appear to be attractive enough for some of the students compared with the possibility of going to work. Also, the amount of the study loan is not sufficient, which is why the students still need additional money. At the same time, it should be noted that while financial support decreases the risk of dropping out, taking out a loan (including study loan) might lead to a greater likelihood of dropping out. Since the IT field offers a vast variety of job opportunities (many vacancies), it also involves the risk that an increase in workload causes the working student to drop out of his or her studies. That is why the possibility of paying bigger scholarships to more students should be taken into consideration.

Recommendations for future studies

The duration of the current study was slightly more than two years. Since this is not a sufficient time period for students to even receive their bachelor's degree, no conclusions can be drawn yet regarding changes in their study motivation or other characteristics during the entire study period. Also, it is not possible to design any necessary activities during such a short period or evaluate their influence on the career choices in the IT field. However, the duration of this study has been sufficient to gain a broader understanding of issues that, at least in Estonia, need to be dealt with further. Therefore, the recommended topics for future studies are listed below.

1. **A study on teaching IT in general education schools.** In Estonia, IT is taught in general education schools in various fields and forms of study. Also, the digital competency was recently added to the national curriculum. For optimum coordination, an in-depth study is needed which would uncover the best practices and offer clearer solutions for remedying any shortcomings. Based on these results, a national informatics curriculum can be developed.

2. **A study on vocational IT education.** In Estonia, more than 2400 people are studying in IT related curricula in vocational schools. A good overview is needed of this field, as well. A comparative analysis of the curricula and studies in vocational education and those in higher education could lead to better organization of both of them.

3. **A study on the future of dropouts.** This would be a longer study which would show whether those who graduate will, in fact, start working in the IT field and what happens to those who drop out – whether they will also start working in the IT field or later continue their unfinished studies. The study should be extended to the master's level, as well. As a result of the study, we should find out whether dropping out is a serious problem and whether potential dropouts should be picked out already in the admissions process or the role of dropouts could, in fact, be important for integrating the IT field with other fields.

4. **A study on working students.** It should be investigated how the proportion of students working in the IT field changes during the entire study period (the current study could only involve the first two study years and therefore, we have no information about the final year of bachelor's studies or about master's studies), what students working in the IT field expect from their studies and how they could best combine their studies and work. The results of this study would be an important input to the collaboration of higher education institutions and IT companies.

5. **A study on the expectations of employers.** This study would focus on the employers' expectations of what IT students should be taught in higher education institutions so that IT graduates could immediately succeed in the job market. What is important here is that future needs should be taken into account – higher education institutions should prepare IT specialists who can successfully manage future problems, not merely the existing ones. A comparison of IT

workers with different backgrounds (higher education, vocational education, no education) would also be very useful.

6. **A study on preparing for IT studies at the higher education level.** This study would concentrate on how to prepare for successful higher education studies. Also, solutions would be offered as to how higher education institutions could support students who have not been best prepared for their studies or students who are a bit lazy and do not take full advantage of their potential. The results of this study should provide new ideas that teachers and lecturers could use for supporting and motivating the learners.

7. **A study on the reasons for the difficulty of basic subjects.** Several studies have shown that dropping out of higher education IT studies is often caused by difficult basic subjects. Therefore, it needs to be investigated why the important subjects in the field (mathematics, basics of programming) are difficult for students, how to make studying these subjects more effective and how to motivate students to study these subjects in depth. Some subjects could be changed in the curriculum, if needed.

8. **Comparative studies with other countries.** The current study involved as advisors experts from four countries, who found that several of our recommendations could also be considered on an international level. Therefore, the results of the current study are worth being distributed more widely, and after that, it would be reasonable to investigate which of these recommendations and how could be applied on a larger scale and how the impact of different factors will manifest depending on country-specific or other factors.

9. **A study on applying the recommendations of the current study.** This would be a follow-up study aimed at finding out if and how the recommendations presented in the current study have been taken into account and what their impact has been.

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