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SEEKING ADEQUATE COMPENCIES FOR THE FUTURE:

The Digital Skills of Finnish Upper Secondary School Students

by Meri-Tuulia Kaarakainen, Suvi-Sadetta Kaarakainen and Antero Kivinen

Digital skills are a prerequisite today for working, studying, civic participation, and maintaining social relationships in our digitalised technical world. These skills are also important both as a general goal and an instrument for learning. This study briefly presents the aims that are related to digital skills of the Finnish curricula, and explores, using a large sample (N = 3,206) of Finnish upper secondary school students, these young people's digital skills and their distribution. The study provides new insights into the state of these skills and differences found in them and focuses on the relationship between these results and the students' present educational choices and future study/employment intentions. The actual variability of digital skills among upper secondary students is one of the main findings of the study. On the same educational level, it was found that digital skills vary enormously, particularly for students' current educational choices and their future intentions. Digital skills are also distinctly associated with age for 15 to 22-year-olds. At the same time, gender alone appears to have no prominent effect on the level or adeptness of upper secondary school students' digital skills.

Keywords: digital skills, upper secondary education, curricula, educational choices, gender

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Introduction

Global trends in rapid technological development and the rise of the digital economy have produced new kinds of competence requirements. Increasingly nearly every job, every level of study, and every field of education, civic participation, and communication and social relationships require at least a reasonable degree of digital skills. This technological development has altered the character of both civic skills and jobs. The new digital economy offers new opportunities and ways to work, but it also requires new combinations of skills and the ability to constantly improve them. In its first phase, digitalisation replaced routine manual work and then manual non-routine tasks. Now it also affects cognitive routines and non-routine tasks and is rapidly displacing lower-skilled workers. Jobs with higher complexity and higher skills requirements are more resilient, and these changes in the labour market have benefited the most skilled workers, particularly for non-routine and cognitive tasks. (European Commission 2016b; Nübler 2016; Levy et al. 2012.) The future labour market will be seeking digitally intelligent workers to cope with emerging, complex, and interactive assignments (van Laar et al. 2017). At the same time, citizens in a digital society are expected to have the skills and knowledge to be able to engage well with digital public services and all ranges of information. Indeed, Smart Cities expects Smart Citizens (e.g., Janowski 2015; Cocchia 2014), as they are described as being in highly technologised environments that use information technologies to adapt to changes in different physical circumstances and easily engage with local people using open innovation processes and e-participation (e.g. Komninos 2013).

There have been numerous efforts to predict the changes in civic life and the labour market brought about by this new technology. However, it has turned out to be difficult to predict specific future professions, so researchers and policy makers have instead sought to outline the skills believed to be required for the future (van Laar et al. 2017; European Commission 2016; 2016b; Davies et al. 2011). According to Davies et al. (2011) the ten most crucial skills for the future workforce are sense-making, social intelligence, novel and adaptive thinking, cross-cultural competency, computational thinking, new-media literacy, transdisciplinarity, a design-mindset, cognitive load management, and virtual collaboration. Many of these future skills are also associated with versatile digital skills.

Van Deursen and Mossberger (2018) remind us that the potential benefits of ubiquitous technologies and digitalisation are accompanied by social costs that include widening inequalities, not only in the labour market, but also in digital citizenship. Users with inadequate skills are less likely to benefit from opening opportunities, are less empowered to make decisions on their own within complex digital services and platforms, and may even suffer a loss of privacy. Ideally, digital citizens possess new forms of information skills and data literacy, including the ability to access, interpret, assess, manage, and use data, the skills to both communicate on social platforms and understand different forms of communication, and the strategic skills needed to make security and privacy control decisions effectively. According to van Deursen and Mossberger (2018), digitalisation may also deepen certain inequalities through the greater use of big data and analytics, for example, those being used for hiring, credit, insurance, health care, and service access. The risk, therefore, rests in the non-representative data (which excludes minorities) behind such automatic decision-making, and these can reinforce existing biases, by producing a false illusion of objectivity (O'Neil, 2016).

When it comes to digital skills, the definitions, viewpoints, and frameworks used in previous studies are numerous. In most cases, these concepts consist of a domain part (such as a computer, ICT, or Internet) and a knowledge perspective (competence, literacy, or skills) (Hatlevik et al. 2015). Van Laar et al. (2017) argue that the current concepts in this area are increasingly taking into account knowledge- or content-related skills that are intending to widen the traditional dominance of technologies in concepts like digital or ICT competency. Van Dijk and van Deursen (2014) recommend using the term "digital skills" as it captures the entirety of transferable skills that are needed for one to be able to use digital media and services successfully in a digitalised society.

As Hoffman and Schechter (2016) point out, digital skills will become a key prerequisite for civic participation, social communication, information searching and processing, academic skills and professional success in future societies. According to Berger and Frey (2016), although all kinds of digital skills are expected to increase in importance in the future, there is a particularly growing demand today for more advanced technical skills in the labour market. This focus makes digital skills necessary for both success and overall professional well-being in a digitalised world. Consequently, digital skills should be considered as desired, even necessary, educational outcomes that students must work to achieve. These skills also need to play a central role in curricula at every educational level. (Aesaert et al. 2015.) This paper thus discusses digital skills in the context of the Finnish curricula, examines the digital skills of Finnish upper secondary school students and indicates how these skills are associated with current students' educational choices, future study/employment intentions, genders, and ages.

Digital Skills and the Finnish Curricula

In the Finnish education system, the upper secondary level is divided into general and vocational upper secondary education, and both provided an opportunity to continue on to the tertiary education level. Upper secondary school students in Finland are increasingly expected to use digital technologies and the Internet when seeking information, preparing texts and presentations, undertaking cooperative learning and communication in school and for homework (e.g., FNBE 2016; FNBE 2012). In Finland, digital skills and information technology skills are not included as a subject of their own in the national core curriculum offered in general and vocational upper secondary education. Instead these skills are taught as part of all separate subjects and study modules (FNBE 2016; FNBE 2012).

In the core curriculum of Finnish general upper secondary schools, digital skills are one of the six transversal competence areas designated as Technology and Society. These skills are targeted to use to overcome educational challenges in the present society and thus implemented in all subjects. The goals are to deepen students' abilities to appropriately use and interact with digital technologies in a responsible, safe, and ergonomic manner – both independently and with others. Students are offered different possibilities to examine and evaluate, for example, topics in the following themes: Technological development and its effects and potentials, the human computer relationship, technological impact and its role for the evaluation of lifestyles, and the interaction of science, art and technology. Further still, the learning goals encourage students to use their potential, creativity, and problem-solving skills to seek and find solutions to hands-on challenges, promote the understanding that mistakes are a part of the creative learning process, enhance cooperation skills, gain experience in entrepreneurship and technology enterprises, develop the competencies needed to make reasonable choices as both citizens and consumers, and gain the abilities to evaluate the interactions between technology, the economy, and public life, and the technological impacts to produce successful occupational restructuration. In addition, the advanced syllabus in mathematics includes a specialised course in algorithmic thinking. (FNBE 2016.)

In Finland, vocational upper secondary education covers 8 fields of education, including more than 50 vocational qualifications. These studies are comprised of both compulsory and optional study modules. (FNBE 2013) The curricula in vocational education consist of a common part for all the fields of vocational education and training and then a qualification specific segment of the curriculum. Technology and information technology skills are seen as a key competence for lifelong learning. The goal is for all students to gain various experiences in the technologies that are used in their profession, have knowledge of all related technological benefits, limitations, and risks, and become versatile users of computer technology as both a professional and a citizen. Digital skills are thus part of the key competencies that are common to all vocational fields. (e.g., FNBE 2012; FNBE 2011a.)

Within this common qualification that is delivered to all the fields of education, digital skills are the study modules for mathematics and natural sciences (e.g., the use of applications, security, and network identity issues, receiving and giving commands, saving and sharing files), communication and media skills (e.g., information and media skills, digital communication), and active citizenship and knowledge of different cultures (e.g., social media and civic participation, e-government services and consumer skills, digital skills for job applicants) (e.g., FNBE 2012; FNBE 2011a). In addition, within these ICT- or technology-related qualifications, the qualification specific part of the curriculum includes program specific study modules, for example, knowledge of the process that occurs from software implementation to software specification and design and the integrated applications for understanding server systems (FNBE 2012; FNBE 2011b).

These curricula provide a foundation on which the skills of future citizens and workers in Finland are built. According to the Official Statistics of Finland (OSF 2016a), a fair 50 percent of students continue on to general upper secondary education and about 40 percent continue on to vocational education immediately after completing their basic education. Less than 10 percent of young people opt out or drop out of their secondary education studies each year. After the secondary level, 37 percent of those who have completed their qualifications in general upper secondary schools in year 2016 continued their studies at the tertiary level or in other forms of education within one year after graduation. In contrast, for the graduates from vocational secondary school, those who are still full-time students one year after graduation only totalled 8 percent. Even though the graduates of general upper secondary school continue their studies on the tertiary level at some point in their lives, for many of these young people, upper secondary school is the last venue where they receive any formal training in digital skills. This knowledge stresses even further the clear importance of reaching an adequate level of these skills during upper secondary level studies, and, this fact should be noted in the curricula of every study program at the secondary education level. Secondary level education is the last chance to reach the majority of each age group and ensure that the adequate skills they need to be a citizen in a digital society and a labour market entrant in today's highly technologised labour market are effectively delivered.

The Digital Skills of Upper Secondary School Students

It has too often been taken for granted that young people possess the competencies they will need to proficiently utilise digital technologies (i.e., Bennett et al. 2008). However, many of the previous studies (e.g., Kaarakainen, Kivinen & Vainio 2018; Kaarakainen, Kivinen & Kaarakainen 2017; van Dijk et al. 2014; Calvani et al. 2012) have learned that this optimistic portrayal of young persons' digital skills is poorly founded. Whereas at the basic education level, the focus of teaching digital skills is to offer students experience with computers and teach some operational skills, at the secondary education level, this instruction focus transfers to content-related digital skills, and indeed pronouncedly, to information skills. Students receive assignments that require the use of the Internet independently for sources. Yet, too often, teachers tend to forget that the general digital skills of secondary education level students are commonly insufficient, and these students need more instruction on these skills. (Van Dijk et al. 2014.) Anzera and Comunello (2014) emphasized that despite the general belief ("surely everyone knows how to google"), information skills are complex by their very nature and cannot be properly or fully acquired without some direct teaching of them. The same is true for general digital skills. Van Dijk and van Deursen (2014) argue that in post-basic level studies, before using any digital technologies for educational purposes, a student's level of digital skills should first be tested. Unskilled students need to be taught the precise skills they need before they can simply be assumed to be able to independently cope with all of the typical digital technologies and digital learning environments.

The systematic review of Siddiq et al. (2016) targeted the finding of having a comprehensive picture of the present state of the field of digital competence assessment in the contexts of both basic and secondary level education. They found that the majority of assessment tools were used with lower secondary level students, and there was a lack of assessment instruments; therefore, only a few of the previous research results, particularly regarding upper secondary level student skills. Based on their analysis, of the majority of assessment tools that measured students' skills related to managing digital information, only a fair half of these tools also measured the skills related to content-creation, digital communication and technical operations. Further, only a few of the assessment tools measured the competence areas that require strategic skills, such as safety or problem-solving (Siddiq et al. 2016.)

As addressed by Siddiq et al. (2016), there are currently not a large number of available studies that relate to upper secondary school students' digital competence. However, these available previous studies do indicate that upper secondary school students lack many of the skills they will need in today's digital environments. For example, in their study, Calvani et al. (2012) showed that Italian upper secondary school students mastered visual literacy (e.g., they could identify menu bars and computer signals) and troubleshooting (e.g., they knew what to do when audio was not heard or a printer did not work) quite well. However, for those tasks that required critical cognitive and socio-ethical skills, these same students' knowledge and competence was found to be inadequate. These results were similar to the observations made by van Dijk and van Deursen (2014), who assumed that young people have adequate medium-related skills (i.e., button knowledge), but they lack particular content-related skills (i.e., information, content creation, and strategic Internet skills.)

Studies of Finnish secondary and upper secondary level students do not unambiguously support the aforementioned assumptions. Instead, previous studies done of Finnish students have indicated that this group of young people have technical or operational skills that are highly overestimated. These students were found to perform satisfyingly on schoolwork-oriented items (e.g., information seeking and word processing), but failed to do the same on technical-oriented items in particular (e.g., basic operations, information networks, different kinds of programming, and database operations) (Kaarakainen et al. 2018; Kaarakainen et al. 2017). This inadequacy in technical-oriented or medium-related skills was due to the fact that the majority of Finnish youth today are well experienced with easy-to-use Smartphones and other mobile devices, but they are not experienced enough in using devices with a wider range of technical capabilities (Kaarakainen, et al. 2017). Another reason for this difference is the major role that self-learning is now playing to deliver these skills to many young people. As van Dijk and van Deursen (2014) argue, learning these digital skills outside of formal education results in acquiring only those skills that are urgent to use at a particular moment. This kind of learning is likely to be only partial, and indeed, many related operations, principles, techniques and applications are simply bypassed for the sake of convenience.

This large variation in digital skills of upper secondary school students has been addressed in previous studies (e.g., Authors et al 2017a; Hatlevik et al. 2009). Hatlevik and Tømte (2009) also found in their study that the Internet safety awareness of Norwegian upper secondary school students varied between schools, classrooms, and students; students' social backgrounds were also a factor in determining their safety awareness. Based on yet another study of Norwegian students in upper secondary level education, both cultural capital and language integration were positively associated with digital competence, meaning that digital competence is at least to some extent distributed across family backgrounds. In the same study, it was also found that self-efficacy and strategic information use predicted these students' digital competence. Further, student academic achievements were found to predict the actual level of digital competence. (Hatlevik et al. 2015.) Earlier, Hargittai (2010) showed that there is a great variety in Internet usage and the skills of young people, and both aspects are not randomly distributed. Rather, higher levels of parental education, being a male, and other socio-economic factors were positively associated with higher levels of web-usage skills. Van Deursen et al. (2011) found that among the common explanatory variable candidates of the same age, gender, and education, educational attainment was the most significant predictor for both medium- and content-related digital skills. More educated people outperformed lesser educated people.

The Survey of Adult Skills, known as the PIAAC (OECD 2016), examines literacy, numeracy, and problem-solving in technology-rich environments, including the skills of 16–24-year-olds. The section on Problem solving in technology-rich environments focuses on skills that are needed in a digitalised society for personal, work-related and citizen-related situations. Both problem-solving and basic computer literacy skills are measured by testing how well test-takers are able to use ICT tools and applications to assess, process, evaluate and analyse information in goal-oriented situations. Based on PIAAC results, young adults (ages 16 to 24) in Finland possess a higher proficiency in technology-related problem-solving compared to the total Finnish adult population. In general, the results among Finnish adults indicated that education had a significant relationship to all measured skills, and those who had taken part in general upper secondary education succeeded significantly better than those who attained skills in vocational upper secondary education. This effect was particularly strong for the skills needed in problem-solving in technology-rich environments (OECD 2012; 2016). Correspondingly, Brunello and Rocco (2017) argued based on the PIAAC data from 17 countries, that the level of proficiency in basic skills revealed that vocational education is less effective than academic education at the same level of education.

Similarly to the above-mentioned research, a previous study of Finnish upper secondary school students (Kaarakainen, et al. 2017) indicated there are also significant differences within the same educational level in students' digital skills, as average students in the general upper secondary schools possessed stronger digital abilities than did those students in vocational upper secondary schools. Still, as mentioned earlier, in Finland, vocational education has several fields of education, and these skills presumably vary a lot for each vocational student depending on the study programmes. Thus, in this current study, this variety of study programmes in vocational upper secondary education was taken into account. Overall, this study sought to explore the digital skills of Finnish upper secondary education students by age, gender, not just current educational choices, but also future study/work intentions. The research goals for this study, therefore, are the following:

1) Examine the level and variation in digital skills for upper secondary school students
2) Analyse the relationship between upper secondary school students' digital skills and their gender, age, current educational choices, and future study/employment intentions

Methodology

Participants

The data for this study were collected in Finland during the year 2017 as part of a project financed by the Strategic Research Council (SRC) at the Academy of Finland. The participants came from 43 municipalities (88 educational institutions) around the country and consisted of 3,206 upper secondary level students between the ages of 15 and 22. Mean age of the participants was 16.73 with a standard deviation of 1.23. Of the participants, 69 percent came from general upper secondary schools, and 31 percent came from vocational institutions. Table 1 summarizes the frequency of these participants by educational choices and gender. In general, a fair 50 percent of Finnish students continue on to general upper secondary education and about 40 percent of those continue on to vocational upper secondary education immediately after completing their basic education (OSF 2016b). Thus, general upper secondary school students were overrepresented in terms of their share of the total population in this current data set. Of the participants from general upper secondary schools, 64 percent were female students, and 36 percent were male students, whereas in the vocational schools, 55 percent of the students were male, and 45 percent were female.

TABLE 1

Educational Choices	Female Students	Male Students
General upper secondary education:		
Basic syllabus in mathematics	627	276
Advanced syllabus in mathematics	778	520
Vocational upper secondary education:		
Culture	26	6
Natural sciences (ICT)	2	20
Natural resources and the environment	3	26
Tourism, catering, and domestic services	81	30
Social services, health, and sports	173	16
Technology, communication, and transportation	58	377
Social sciences, business, and administration	112	75

Table 1: Frequency of participants' educational choices and their designated genders.

Measurement

The data were collected using an instrument called the ICT skill test that was developed in the Research Unit for the Sociology of Education (RUSE) at the University of Turku (Kaarakainen 2018). The test starts with questionnaires that collect the students' background information (age, gender, postal code, and education level), current educational choices (general upper secondary school or vocational institution, whether the student was a general upper secondary school student participating in a basic or advanced syllabus in mathematics or not, and if the test-taker came from a vocational upper secondary school, was she/he studying culture, natural sciences (ICT), natural resources and environment, tourism, catering and domestic service, social services, health and sports, technology, communication and transport, or social sciences, business and administration).

Voluntary digital activity was gathered as usage activity for the following specific purposes: Maintaining social relationships, communicating, running daily errands, following the news, searching for information, creating digital content, sharing digital content, playing digital games, consuming digital entertainment, and studying using digital technology. Schoolwork-related digital activity (use of devices, online services and software and digital educational materials for learning at school), and the participants' future intentions were also compiled (the field (ISCED-F) for where they desired to study or work after graduating from their current educational plan). In this study, only their demographic information, current educational choices and future intentions were analysed concurrently with the test performance information.

The actual test was undertaken after the questionnaires were completed. The ICT skills test consisted of 18 items (see Appendix 1) divided into 6 modules based on item topics (see Figure 1). Each item consisted of multiple subtasks (1–6) and/or chains of actions in which every action (selection or operation) was linked to the previous one; together they formed a coherent item. For these items, a combination of close-ended questions (conventional multiple-choice, true-false multiple-choice, multiple true-false multiple-choice, and matching) and open-ended questions or questions requiring the participants to interact with the test environment (input the right values or select and click the right function icons) were applied (see examples in Figure 2). The majority of these items can be seen as context-dependent item sets (cf. Haladyna et al. 2002), as they consist of a problem scenario for the participants to solve by choosing the right actions from given options related to a progressive storyline. In the ICT skills test, the interest is not simply on does the test-taker get the item completely right, but how much of each item requirements test-taker masters. Scores for each item ranged from 0 to 2 resulting in a total score of 36. Items were assessed automatically based on specified options and actions or simple text mining algorithms.

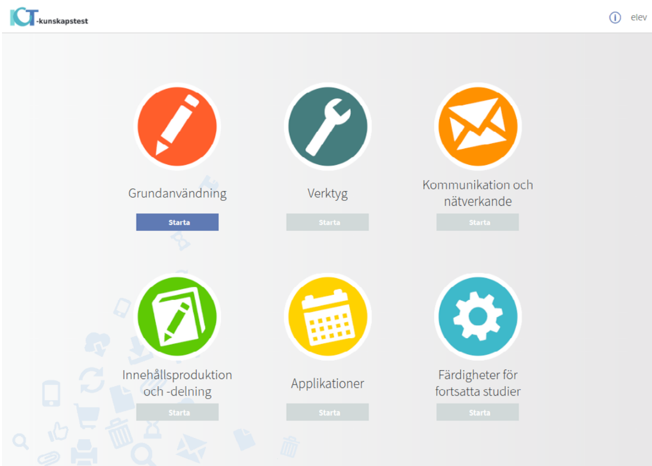

Figure 1: Six modules (basic operations, office tools, communication and networking, content creation, applications, and prerequisites for ICT-related studies) of the ICT skills test (all print screens are from a Swedish user interface)

The test items were implemented in such a way that the user interface and the graphics attempted to simulate common ICT applications and hence mirror real-life settings. The test was bilingual, as both Finnish and Swedish are official languages in Finland. The ICT skills test was implemented as a web application, written in PHP and JavaScript languages, using the TinyMVC- and Bootstrap-frameworks. That application is supported by PostgreSQL database software for storage purposes. The tested competence areas (15/18 items) were chosen based on the Finnish national core curriculum for basic education, wherein digital skills are one of seven transversal competences that are integrated into all subjects so as to offer every student the following skills: Understanding of the basic operations and concepts of ICT, the knowledge to use ICT in a responsible, safe, and ergonomic manner; the abilities to use ICT as a tool for information management and creative work; and the competence to use ICT for both interaction and networking (FNBE 2016). The last three items are broadly based on the curriculum of the information and communications technology field in Finnish vocational upper secondary schools and the Universities of Applied Sciences. The Cronbach's alpha for the ICT skills test (all 18 items) was .86, which exceeded the common threshold of .7 (Nunnally et al. 1994). The results of a more specific item-level analysis were presented in a previous study (Kaarakainen 2018). In this current study, however, the ICT skills test scores are only considered at the total score level.

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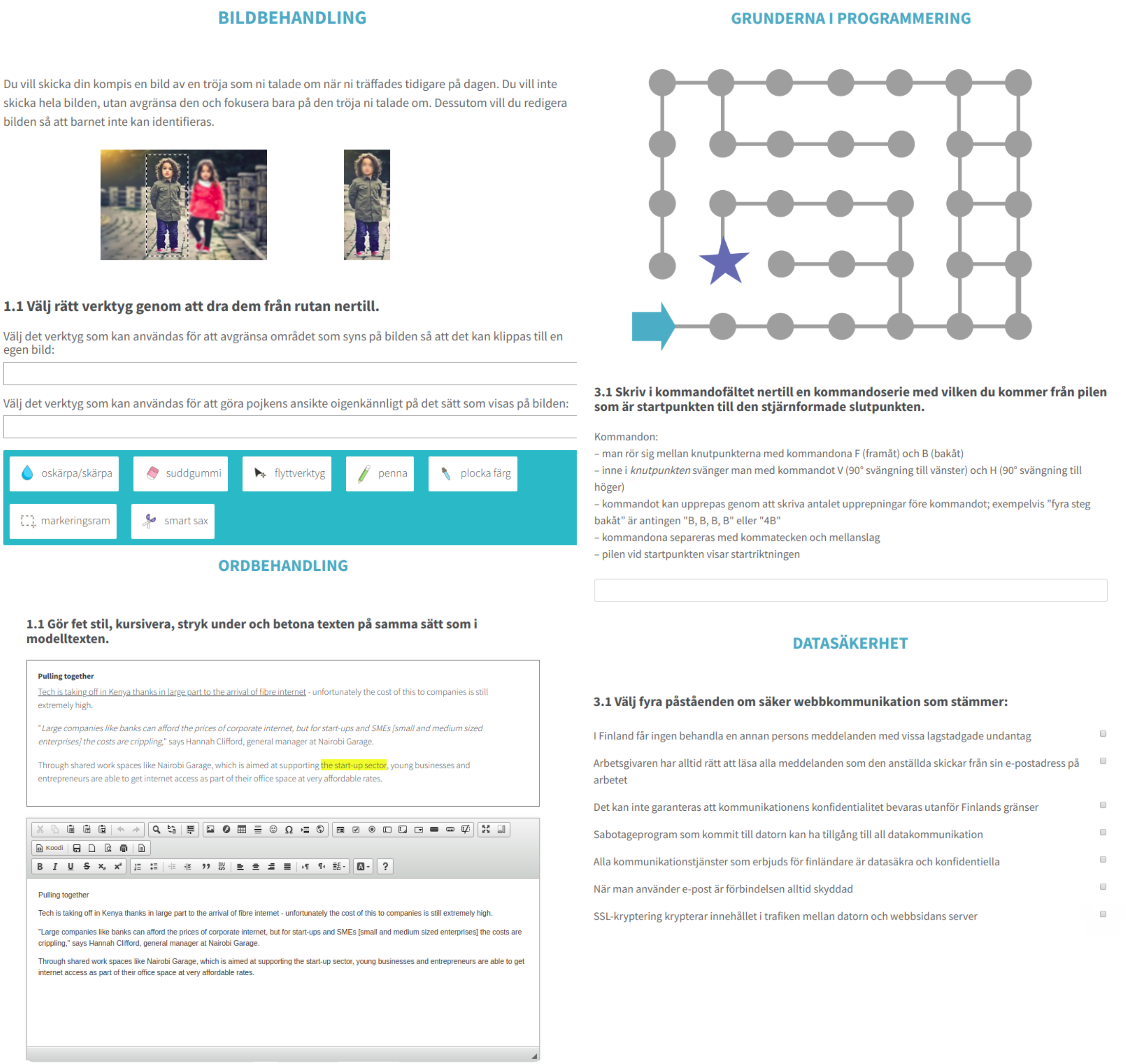

Figure 2: Examples of items: a matching type multiple-choice item (top left; image processing), an open-ended item (top right; elementary programming), an interactive item (bottom left; word processing) and a true-false multiple-choice item (bottom right; information security) used on the ICT skills test (see item requirements in English in Appendix 1).

Analysis of the Data

The first research goal addressed in this paper, namely, the level and variation of upper secondary school students' digital skills, was answered by examining the variable range, means and standard deviations, and the differences between the genders for these scores. These scores were analysed by using an independent samples t-test, as it is a suitable test to use to compare the sample means from two independent groups for at least interval-scale data (see e.g., Warner 2013). A Chi-squared test was utilised to test the differences between the genders in popularity of the fields for both current educational choices and future study/work. The Chi-squared test is a common statistical hypothesis test used to determine whether there is a statistically significant difference between the expected frequencies and the observed frequencies in one or more categories being tested (Greenwood et al. 1996).

The associations between students' current educational choices and their future study/employment intentions using digital skills were examined by analysing first the test scores by study programmes or by future intentions (ISCED-F fields) and then further case-by-case by gender. One-way analysis of variance (ANOVA) was used to test the differences between the study programmes. ANOVA is a common statistical method used for comparing three or more group means. If the ANOVA is significant, then a post-hoc comparison between these same groups is necessary to identify the specific significant differences between each pair of groups. In this study, pair-wise comparisons were conducted using the Bonferroni method. (Rupert 1997.) After comparing the means between different study programmes/future intentions, an independent samples t-test was used to test the differences between the genders within each specific study programme.

Multiple linear regression analysis was used to analyse the relationship between upper secondary school students' digital skills, gender, age, current educational choices, and future intentions. Multiple linear regression is an extension of simple linear regression. It allows one to answer questions about the kind of a role multiple independent variables play when accounting for any variance of a dependent variable (Nathans et al. 2012). This analysis was run separately for students in the general upper secondary schools (GUSS) and those in vocational schools (VUSS) since the background variables for these students were different. The R-squared values for the following two models remained low: For general upper secondary school (13 variables) adjusted to $R^2 = .09$, and for the vocational schools (18 variables) adjusted to $R^2 = .22$. The low R-squared values do not mean that the regressors were inappropriate; it simply suggests that the models missed certain explanatory variables (Marsh et al. 2002), and the skills to explain a much more complicated group of factors than those examined in this study. The autocorrelation influence was assessed using the Durbin-Watson test. The Durbin-Watson statistic d ranges from 0 to 4, and should be near 2, as low d values (near 0) indicate a positive serial correlation; high d values (near 4) indicate that successive error terms differ from one another (Durbin et al. 1951).

Chasing a more accurate view of the associations of age, educational choices, and digital skills, the performance mean scores were separately visualised by age for the general upper secondary school students (GUSS) and the vocational upper secondary school students (VUSS). The differences between the students in these two groups at each age point were analysed using an independent samples t-test.

Results

The ICT skill test total scores ranged from 0 points to 32 points (maximum points on the test were 36) indicating that the variation in different students' skills was extensive. The mean score of all 18 items was 12.41 with a standard deviation of 5.74, meaning that on average, students achieved only one-third of the available points from the ICT skill test. The mean score for male students was 12.84 (SD 6.41) and for female students, 12.11 (SD 5.18), and the difference between the two was statistically significant ($t = -3.422$, $p = .001$). Further analysis revealed that the mean scores for the ICT skill test varied more between those students in different study programs than between the genders as shown in Figure 3. These differences, based on a one-way analysis of variance, between the different study programs were highly significant ($F(8, 3184)= 36.830$, $p < .001$).

Figure 3 shows the mean scores on the ICT skill test by gender and current educational choices. When examining the gender differences within educational choices, it should be noted that gender distribution in educational choices were significantly unequal for both the general upper secondary education mathematics studies ($X^2 =23.285$, $df = 2$, $p < .001$) and fields of study in vocational education ($X^2 =435.484$, $df = 6$, $p < .001$). Students from vocational upper secondary schools who studied vocational qualifications in information and communications technology (natural sciences (ICT)) performed best on the ICT skills test. Even when the bar of female students on the bar chart (Figure 3) were notably higher, the difference between the genders for the mean scores was not significant (see more of the details on gender differences in Appendix 2). This result was due to the unequal sample size (male dominance in the field of natural sciences), which reduced the statistical power (see Rusticus et al. 2014). The students from vocational upper secondary schools, who studied a field of culture (vocational qualifications in audio-visual communication) ranked second, and students from the general upper secondary schools, who studied an advanced syllabus in mathematics, ranked third. Among the audio-visual communication students, gender differences were not significant, but among the general upper secondary school students studying an advanced syllabus in mathematics, male students outperformed the female students (see Appendix 2). After the top three ranked in vocational upper secondary education came those students from the social sciences, business and administration and technology, communication and transportation study programs, and then general upper secondary school students who studied basic syllabus in mathematics. No statistically significant differences between the genders were found among these groups (see Appendix 2). Among the bottom three were vocational upper secondary school students from programs in natural resources and environment, tourism, catering and domestic services, and social services, health and sports studies. Again, there were no significant differences between the genders for any of these groups (see Appendix 2).

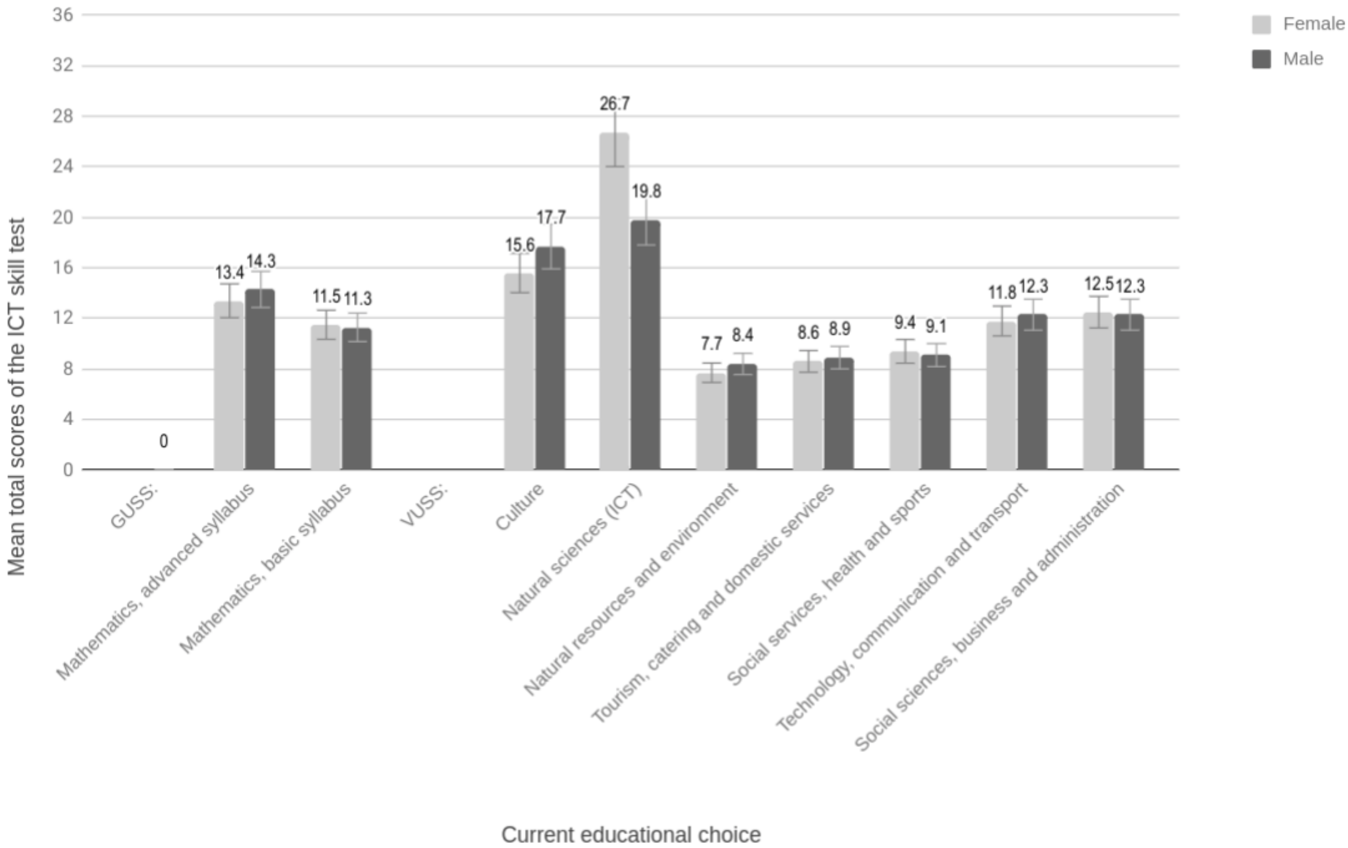

Figure 3: Mean scores on the ICT skill test by gender and current educational choices with error bars.

Figure 4 represent the popularity of fields of future intentions among students by gender. The Chi-square test indicated that among Finnish upper secondary level students there existed significant differences in the popularity of fields of future study/work between the genders ($X^2 = 776.389$, df = 9, $p < .001$), except in the field of business, administration, and law, which was popular for both genders and the fields of agriculture, forestry, fisheries, and veterinary, which in turn were unpopular for both genders. The most popular field for female students was health and welfare, whereas for male students, engineering, manufacturing and construction were clearly the most popular fields for future studies or work. Among the female students, the fields of business, administration and law, education, arts and humanities, and social sciences, journalism and information were also popular choices for future study/employment. On the contrary, the ICT field was the most unpopular choice among female students, and agriculture, forestry, fisheries, and veterinary ranked right after ICT in unpopularity. Among male students, the fields of business, administration and law, and ICT ranked next after engineering, manufacturing and construction. The most unpopular choices for males were social sciences, journalism and information, education, and agriculture, forestry, fisheries and veterinary.

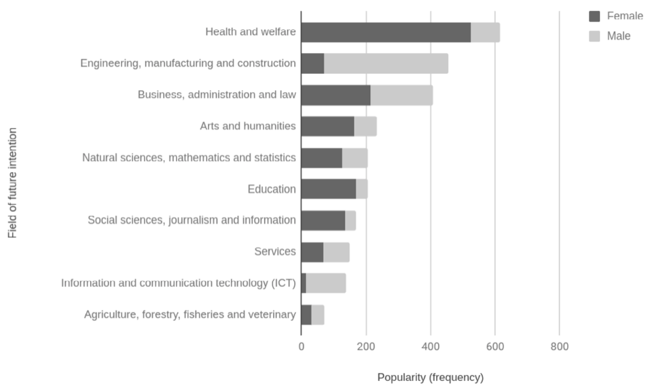

Figure 4. Student popularity of fields for future study or employment by gender among students.

Figure 5 indicates the mean scores on the ICT skill test by future study/employment intentions and by gender. The differences in digital skills between students with different future intentions were highly significant (ANOVA: $F(9, 2958) = 30.976$, $p < .001$), as students' aiming for ICT or other STEM fields outperformed the other students. In turn, digital skills were the most insufficient for those students' aiming to enter the fields of education, services and agriculture, forestry, fisheries and veterinary. Based on an analysis of an independent sample t-test, there were no significant differences between the genders among students within the same field of future intention, except for students' wanting to enter STEM fields. Within that student group, male students outperformed the female ones (see Appendix 3 for more details).

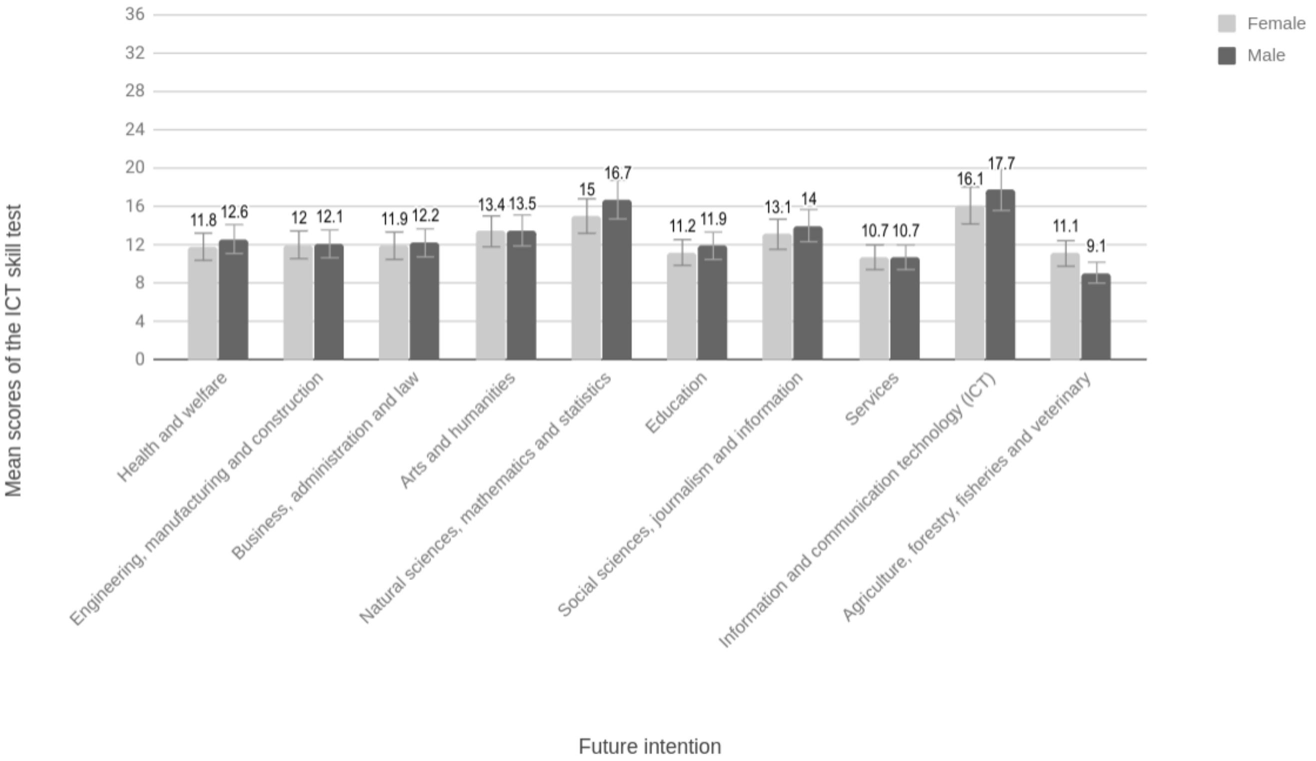

Figure 5: Mean scores on the ICT skill test by gender and current educational choices with error bars.

TABLE 2

	GUSS			VUSS		
Predictors	B	SE	β	B	SE	β
Gender (female = 0 / male = 1)	-.334	.260	.260	-.223	.459	-.018
Age	.604	.128	.098***	.781	.109	.207***
Current Educational Choices:						
Syllabus in mathematics (for GUSS only):						
Basic (= 0) / Advanced(= 1)	2.123	.241	.193***			

Studies in certain fields (for VUSS only):						
Culture				2.257	1.173	1.173
Natural sciences (ICT)				3.678	1.297	1.297
Natural resources and the environment				-1.449	1.500	1.500
Tourism, catering, and domestic services				-2.360	.786	.786
Social services, health, and sports				-1.358	.850	.850
Technology, communication, and transportation				1.220	.617	.617
Social sciences, business, and administration				1.309	.740	.740
Future Intentions:						
In the future, student wants to study/work in:						
Education	-.606	.559	-.030	-3.095	1.357	-.085*
Arts and humanities	.989	.548	.050	.035	1.229	.001
Social sciences, journalism and information	.912	.577	.042	-1.702	1.770	-.031
Business, administration and law	-.520	.798	-.031	-1.564	1.051	-.085
Natural sciences, mathematics and statistics	2.241	.557	.114***	3.033	1.783	.055
Information and communication technology (ICT)	3.961	.795	.116***	4.562	1.021	.204***
Engineering, manufacturing and construction	-.309	.550	-.016	-.802	.850	-.058
Agriculture, forestry, fisheries and veterinary	-1.390	1.016	-.030	-2.200	1.475	-.071
Health and welfare	-.199	.462	-.015	-2.064	1.113	-.116
Services	-.903	.519	-.051	-1.395	.882	-.097
R	.31			.48		
Adjusted R^2	.09			.22		
F-value	17.197***			16.334***		

B = the unstandardised beta, SE = the standard error for the unstandardised beta, β = the standardised beta,
* p < .05, ** p < .01, *** p < .001t

Table 2: Multiple regression models for general (GUSS) and vocational upper secondary school (VUSS) students.

Two separate multiple regression analyses were performed (see Table 2), one for general upper secondary school students and one for vocational upper secondary school students. Table 2 presents the results of the analysis of general upper secondary school students and vocational upper secondary school students and their respective data sets. This analysis showed that digital skills among general upper secondary education students were significantly predicted by age, an advanced syllabus in mathematics, and the intention to further study/work in STEM or ICT ($R = .31$, adjusted $R^2 = .09$, $F(13, 2187) = 17.197$, $p < .001$). The best predictor of digital skills among the general upper secondary school students was an advanced syllabus in mathematics (standardised beta coefficient, $\beta = .193$). Also the intention to study or work in ICT ($\beta = .116$) or a STEM ($\beta = .114$) field in the future, and age ($\beta = .098$) was associated positively with these students' digital skills.

For vocational schoolers, the analysis showed that digital skills were predicted by age, studying ICT (positive predictor) or tourism, catering and domestic services (negative predictor) and the intention to further study or work in the ICT field ($R = .48$, adjusted $R^2 = .22$, $F(18, 986) = 16.334$, $p < .001$). The best predictors of digital skills among the vocational upper secondary school students were age ($\beta = .207$) and the intention to study or work in the ICT field in the future ($\beta = .204$). Further, studying the fields of natural sciences ($\beta = .089$) and culture ($\beta = .079$) increased the digital skills, whereas studying the tourism, catering and domestic services fields ($\beta = -.124$) significantly decreased these particular skills as well as the intention to study/work in the field of education ($\beta = -.085$) in the future. The Durbin-Watson d value for the GUSS (1.553) and VUSS (1.573) models indicated no major problems with autocorrelation.

Figure 6 offers the ICT skills test mean scores by age and current educational choice. Before this analysis and visualisation, all students older than 19 were removed because there were no 19+ year old students in the general upper secondary schools, and only a few in the vocational upper secondary schools. In Finland, the typical graduation age from upper secondary education is 18 or 19. Vocational upper secondary schools usually have older students due to dropouts who later return to studies and the fact that some graduates from general upper secondary schools do continue their studies in vocational upper secondary schools instead of applying to the tertiary level. As was clearly seen, at the beginning of the upper secondary level at the age of 15, students in the general upper secondary schools outperformed the vocational education students (GUSS: M 12.37, SD 5.49; VUSS: M 7.97, SD 5.10; $t = 5.629$, $p < .001$). At the age of 18, there were no longer any significant differences between the school types (GUSS: M 13.74, SD 7.44; VUSS: M 13.58, SD 5.68; $t = .100$, $p = .920$) as the vocational schoolers had closed the gap during their three-year degree studies.

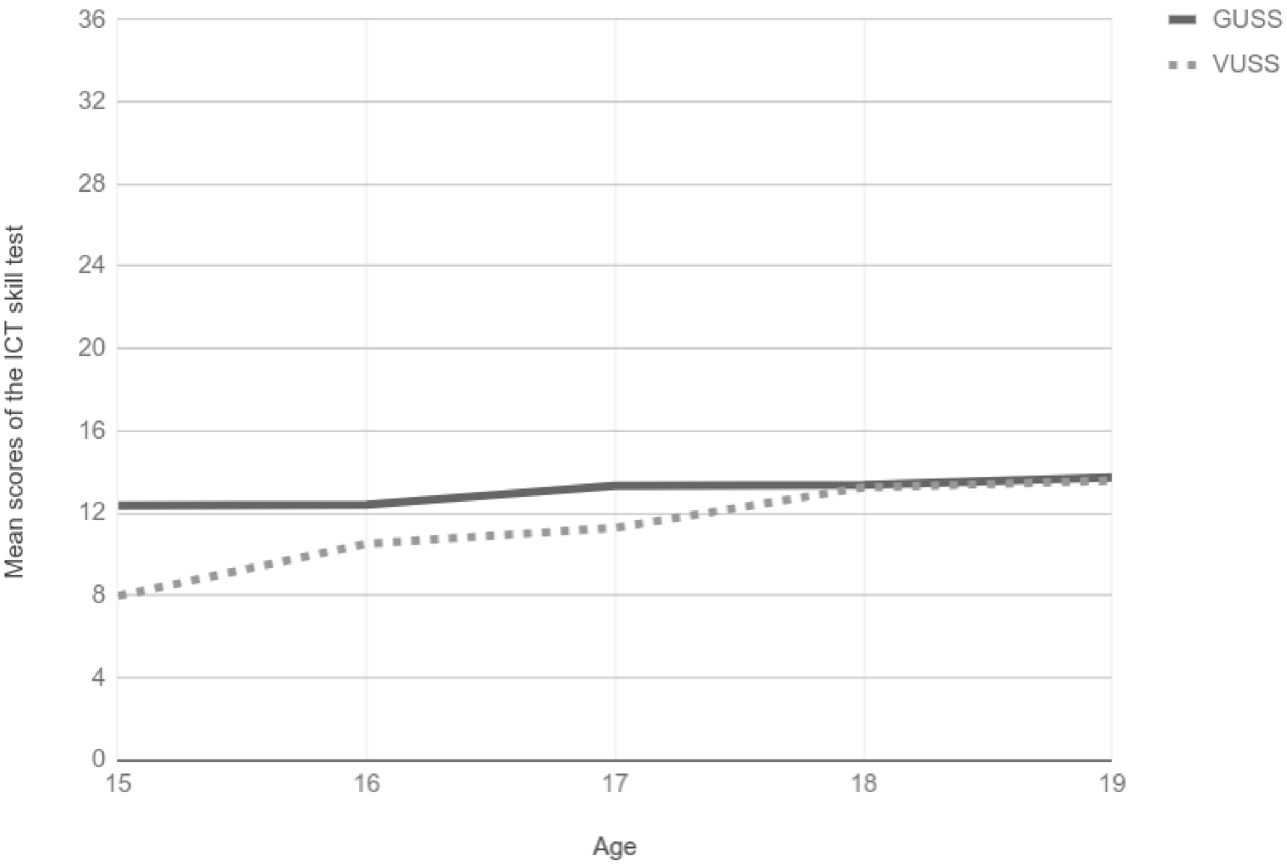

Figure 6: ICT skill test performance by age and educational choice.

Discussion

As mentioned earlier, Siddiq et al. (2016) noted that the majority of the present assessment tools were developed to measure digital competence for lower level students; therefore, these authors encouraged researchers to develop tests for primary and upper secondary level students. This study and the developers of the ICT skill test accepted this challenge. The ICT skill test is specifically developed for upper secondary education students. The vast majority of tasks are, therefore, quite demanding, as the test is targeting satisfactory item level discrimination power between high and low performers aiming to expose potential uneven digital skills.

The variability of digital skills among upper secondary education students is one of the main findings of this study. At the same educational level, some students were not able to solve any of the presented assignments, while the most capable students successfully solved almost 90 percent of these tasks. The average performance level on the ICT skills test for Finnish upper secondary school students was relatively low, as these students had mastered on average only one-third of the skills being tested. This result is in line with the considerations of van Dijk and van Deursen (2014), who criticised the overestimation of young people's digital competences. The results also stress the need to focus on integrating digital skills into upper secondary level teaching, rather than simply relying on the assumptions that students already possess these skills when they transition from basic education to upper secondary education.

On average, the results of this study indicated that male students outperformed female students by a slight, but still a statistically significant margin. However, when the gender differences were analysed separately based on current educational choices and fields of future study/work intentions, gender had no prominent effect on the digital skills of the students. This finding was confirmed by regression analyses, wherein gender proved not to be the significant predictor of students' digital skills. On the contrary, current educational choices and the specific field of future study/employment intention had a notable impact on students' digital skills. Particularly the intention to work or study in ICT or other STEM fields in the future appeared to be associated with the current level of digital skills.

Among Finnish general upper secondary school students, current attendance in advanced syllabus studies in mathematics predicted higher scores on the ICT skills test. In turn, among vocational upper secondary school students, their current attendance in the culture or natural sciences predicted higher performance, while attendance natural resources and environment, tourism, catering and domestic services, or social services, health, and sports were associated with lower digital skills. The dominance of educational choices over gender, therefore, was in line with the previous results of van Deursen et al. (2011) according to which, among the common explanatory variable candidates, education was the most significant predictor of digital skills.

However, unlike what van Deursen et al. (2011) assumed, the cause of this particular observation is probably not the equalisation of education in terms of gender distribution, because as the results of this current study indicated, the gender distribution in students' current educational choices and future intentions was notably unequal. Among the highest performing natural sciences students, the under-represented female group succeeded at least as well as males did, while in turn, in the lowest performing female-dominated fields, male students possessed digital skills that were as weak as those among females. These results indicate that students with higher digital skills and an interest in the ICT sector drift toward particular study programmes at the upper secondary level. Thus, the actual cause of uneven digital competence originates in the previous level of education.

This phenomenon places extra pressure on basic level education, as it should ensure greater equality in digital skill development for all students. As van Deursen and Mossberger (2018) remind us, the potential benefits of digitalisation are accompanied by widening inequalities for those who are not well prepared. If the digital divide among young people cannot be moderated during their common basic education, these uneven opportunities accumulate further during their upper secondary education studies and may then cause serious inequality in prospects for future labour market entrants and digital citizens. The under-representation of females and girls in the STEM fields, particularly ICT, also calls for further educational actions to reduce the existing gender gaps in these well-employed sectors (e.g. Dass et al. 2015). As Cheryan et al. (2016) argue, girls should be offered early experiences with technology, digitalisation, and the professional possibilities they hold as their unwillingness to apply to these fields tends to develop at an early level of education. The same is most probably true with technology non-savvy boys. For this reason, earlier interventions aimed at reducing digital inequality should be scheduled in early stages of common basic education.

Age was noticed as a factor that predicted the level of digital skills among students of both school types. The positive effect of age was even higher among Finnish vocational upper secondary schoolers, who improved their skills during the upper secondary level studies to the extent that they closed the skills gap that existed between general and vocational upper secondary school students by the beginning of their upper secondary level studies. Instead, the development of digital skills among general upper secondary education students was found to be more diminutive. This observation is interesting, as the previous assumption was that vocational education is not as effective as academic education, in this case general upper secondary education, in terms of outcomes for including such skills (see Brunello & Rocco 2017). These findings also lead one to turn more attention to the curricula. Fenwick (2011) argued that government-led reforms in curriculum, assessments, and schooling are aimed at improving national productivity and social well-being. In general, the conceptions about future citizenship and the crucial skills citizens will need in a future society are manifested in curricula (Olson et al. 2014).

The Finnish national core curriculum for general upper secondary education seeks to deepen students' abilities, which are generally learned at the basic education level. Then these students can use, learn, and interact with digital technologies in the future (FNBE 2016). In Finland, the Matriculation Examination at the end of general upper secondary school is the only examination that can be considered as a national, high-stakes examination. Indeed, it may have a strong impact on students' later opportunities. Currently, this examination is undergoing digitalisation, and all of its sub-tests should be digitalised by year 2019. (Pollari 2016.) Understandably, this change has had a significant impact on the teaching, as teachers are now pronouncedly focusing on ensuring that their students have the needed skills to cope with the new examination.

In contrast, in common parts of the vocational upper secondary education curricula, the goal is to offer students experience in the technologies that will used in their profession and support the versatile use of computer technology as both a professional and a citizen (FNBE 2012; FNBE 2011a). The goals for digital skills in the core curriculum for vocational upper secondary education are more oriented toward students' future professions and their adult life. They are more instructive and, with all probability, more motivating for these students, and indeed that focus may cause a definite observed increase in digital skills. However, this issue needs to be more carefully examined in the future.

In general, the results of this study highlight the importance of recognising the need for teaching digital skills at all levels of education. These skills should not be viewed as a sideline of or an "extra" to more important educational goals, nor should the schools assume that all young people already have sufficient digital skills for the future. Instead, it is important to recognise the necessity of digital competence both in the work life and a civic society and work harder to promote both the equality of these skills and exploitation of the many opportunities that are available in the future.

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APPENDIX 1

Item	Description
Basic operations	Participants must pair a keyboard shortcut with a correct action and choose a correct type of computer memory for the present education situation.
Information seeking	Participants have four cases wherein they have to choose a correct source/channel, out of three offerings on where to seek further information on a given topic. After this action, they are presented with a list of search engine results and asked to choose relevant items related to a given scenario.
Information networks	Participants are given four network usage scenarios and must pair them with correct data transmission technologies and then match the correct descriptions to the computer network-related concepts.
Word processing	Participants are asked to edit (bold, italicise, underline, and/or highlight) a given sample text.
Spreadsheets	Participants are asked to fill a spreadsheet table with given information, bold a header row, and sort the table in ascending order.
Presentations	Participants are given a general user interface view of presentation software with essential sections marked. The task is to pair a correct name with the right section of this view.
Social networking	Participants have to pair correct social networking services with four service descriptions, define the meaning of social networking service, and choose four items out of nine that relate to the security of social networking services.
Communication	Participants have to fill in the receiver fields (carbon copy, and blind carbon copy) of an email, add an attachment according to instructions, then identify the types of information that can be used to identify Internet users.
Information security	Participants have to choose correct statements for secure network communication and choose from alternatives those that would relate to the information security of computers in an Internet cafe abroad.
Image processing	Participants have to select correct image processing tools for cropping an image and make the person appearing an unrecognisable image. Afterwards, participants have to choose the correct image processing using related statements from given options and choosing the correct file formats for vector graphics.
Video and audio processing	First, participants have to choose those methods that can be used to edit video footage from a single camera and then choose a right answer to the question: "Which one of these alternatives is related to lossy audio compression?"
Cloud services and publishing	In the first step, participants have to choose which of the given statements about Cloud services are true. In the second step, they must choose the correct YouTube-video sharing option that enables limited sharing even to those who do not have an account on YouTube. The third step is a continuation question: "Can we now be certain that this video does not circulate to the rest of the Internet for outsiders to see […]?"
Software purchasing	Participants have to choose what aspects need to be considered when evaluating the information security of mobile applications and also choose the correct definition of personal data protection from four offered alternatives.
Installation and updates	In the first step, participants choose whether a statement is about an installation or an upgrade; in the second step, they choose whether that same statement is related to an update or to an upgrade.
Elementary programming	Participants have to write, per instructions, a maze traversing script that leads from a starting point to the end. Afterwards, they are presented a short pseudo-code and have to write the value of a particular variable after the given code has completed.
Database operations	Participants have to form an SQL-query, based on given instructions and a simple database diagram, and then choose the right definition for the concept 'NoSQL database'.

Web programming	Participants are given three files (HTML, CSS, and JavaScript) to use to create a website and the view generated by these three files. Participants then answer four multiple choice questions to edit the simple web page view and the dependencies between the given files.
Programming	This programming task requires the participants to place lines of Java code in the correct places based on given comment sections.

Appendix 1. ICT skills test items and their descriptions.

APPENDIX 2

	Female Students		Male Students			
Future Intentions:	**M**	**SD**	**M**	**SD**	**t**	**p**
Advanced syllabus in mathematics	13.41	4.97	14.34	6.43	-2.783	.005**
Basic syllabus in mathematics	11.48	4.79	11.30	5.94	.479	.632
Culture	15.59	5.34	17.72	5.09	-.987	.382
Natural sciences (ICT)	26.65	.35	19.78	6.67	1.424	.170
Natural resources and the environment	7.69	5.57	8.35	4.50	-.236	.815
Tourism, catering, and domestic services	8.59	4.70	8.90	4.89	-.305	.761
Social services, health, and sports	9.40	5.52	12.33	6.36	.224	.823
Technology, communication, and transportation	11.77	5.65	12.34	5.24	-.639	.523
Social sciences, business, and administration	12.51	5.53	12.20	6.34	.203	.840

** $p < .01$

Appendix 2. Digital skills by educational choice and gender.

APPENDIX 3

	Female Students		Male Students			
Future Intentions:	**M**	**SD**	**M**	**SD**	**t**	**p**
Health and welfare	11.75	4.92	12.62	6.52	-1.468	.868
Engineering, manufacturing, and construction	12.03	5.47	12.14	6.18	-.139	.110
Business, administration, and law	11.90	5.44	12.23	6.06	-.574	.567
Arts and the humanities	13.43	5.16	13.48	6.29	.074	.941
Natural sciences, mathematics, and statistics	15.03	5.28	16.65	5.63	-2.077	.039*
Education	11.19	4.83	11.93	6.23	-.802	.424
Social sciences, journalism, and information	13.09	4.95	13.96	5.67	.871	.385
Services	10.71	5.09	10.65	5.82	.129	.897
Information and communication technology (ICT)	16.07	5.70	17.74	6.58	-.911	.364
Agriculture, forestry, fisheries, and veterinary	11.08	5.44	9.07	4.76	1.664	.101

* $p < .05$

Appendix 3. Digital skills by future study/employment intention and gender.