ICT Intentions and Digital Abilities of Future Labor Market Entrants in Finland[1]

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ABSTRACT

Daily lives of citizens in current societies have changed with the spread of digital technologies, online services, and digital communication. Alongside this, the information and communication technology (ICT) labor force is expected to grow massively over the next years, requiring increased number of applicants for digital education and sufficient digital skills from every labor market entrant. This study examines the digital abilities of Finnish upper secondary school students (N = 3206) and the students' intentions to study/work in the ICT field in the future. The results highlight a dissonance between the growth expectations and the popularity of the ICT field among young Finns. The students' future intentions are also strongly gendered; for about 9% of males, but only about 1% of females in secondary education are planning to apply in the ICT field in the future. The students' ICT intentions were predicted most strongly by being a male and possessing strong technical abilities.

KEYWORDS

Digital abilities / gendered educational choices / the ICT field / programming / students

Introduction

Characteristics for the present information society are the central role of information, presence of collaborative platforms, the convergence of content across platforms, the growing importance of cyber security, mobile, and cloud computing, and the automation of routine tasks (Dass et al. 2015; Webster 2014). Along with technological development, new competence requirements have emerged and, like Berger and Frey (2016) argue, although digital skills in general are expected to increase in importance in the future, there is particularly demand for more advanced technical skills. One example is competence in software development, which has grown in importance in many countries as a result of the restructuring of the information and communication technology (ICT) field. Accordingly, not only sufficient digital skills but also computational thinking and coding have been assimilated into a set of skills required from the future labor market entrants (e.g., Bocconi et al. 2016). As a consequence, in several countries, computer science has been introduced to primary and secondary school curricula with aims to provoke computational and algorithmic thinking, teach problem solving and basics of programming, and familiarize children and young people with careers paths that the ICT field professions have to offer (Hubwieser et al. 2015).

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In the digital labor market, there is an ongoing occupational restructuring, the main drivers of which are technological development and offshoring. Due to this evolution, the demand in the labor market is shifting in favor of more educated workers (Goos et al. 2014). For example, in Finland, significant industry-level changes in the 21st century have transformed the ICT field from traditional manufacturing activities to high value-added activities including R&D and software development. These changes have not only had an indisputable impact on the labor market in the ICT field but also have even more broader implications. In this restructuring process, low-skilled workers in the ICT manufacturing and services have been gradually replaced by newer highly skilled labor in the software industry (Nikulainen & Pajarinen 2013). For this reason, at the same time, there may be both an oversupply of employees with obsolete skills and a growing demand for new kind of skills in the field.

On the basis of a forecast scenario, the ICT labor force in Europe will grow from 7.5 million in 2014 to 8.2 million in 2020. That means a need for approximately 756,000 additional workers. Of these, about 70% are expected to be ICT practitioner occupations and around 30% will be at the ICT management level. This scenario also forecasts a structural shortage of 509,000 employees caused by a lack of available and appropriately skilled applicants (Korte et al. 2014). According to a country comparison (OECD 2017), the Finnish workforce had the highest proportion of ICT specialists. Nevertheless, in Finland, there is a growing demand for software developers; it is estimated that there is an immediate need for 7000 software development professionals and the same serious lack of software professionals also harms other Nordic countries (Otivr 2018). The growing demand of digital workforce and rapid changes in skill requirements (e.g., Kauhanen 2016) necessitates bringing motivated young applicants into digital education, and challenges the educational systems at all levels. This empirical study aims to give insight into digital skills of secondary school students, especially their programming skills, and the students' willingness to study or work in the ICT field in the future. Although the subjects of the research are young Finns, it offers perspectives for wider consideration in Scandinavia, as the shortage of digital workforce affects the Nordic countries in general.

General digital abilities and online engagement

Most of the frameworks of 21st century competencies share agreement on basic competencies that citizens nowadays must have. These are, namely, collaboration, communication, versatile literacy skills, including the digital literacy, and both social and cultural competencies. These competences are also seen as vital criteria in the labor market; consequently, young labor market entrants need to acquire such skills in order to enter the workforce (van Laar et al. 2017). The recently recommended term of digital skills is not restricted just to the use of computers or other devices, but also to skills like information management, collaboration and communication, content creation, ethics and responsibility, critical evaluation and problem solving, and technical operations (e.g., Ferrari 2012; Helsper & Eynon 2013; van Laar et al. 2017).

Van Dijk and van Deursen (2014) divided digital skills into medium- and content-related digital skills. According to them, medium-related skills refer to the technical aspects needed for use of digital technology. They consist of operational skills (technical abilities to use the Internet or a computer) and formal skills (abilities to navigate and browse through the Internet). Content-related skills in turn are the substances enabled by the competence to use technology. Content-related skills consist of information skills (abilities to search, select, and evaluate digital information), communication skills (abilities to communicate and to build networks online), content creation skills (abilities to write blogs or tweets, or edit images), and strategic skills (abilities to use technology to reach goals). In the Nordic countries, girls have not been found to lag behind boys in digital competence, rather the opposite (Hatlevik et al. 2017), although in the most technical tasks, boys tend to outperform girls (Kaarakainen et al. 2018). The competencies of future citizens are primarily delivered through the education system. Therefore, as van Laar et al. (2017) disclosed, the changing skill requirements pose serious challenges to educational systems and curricula, as they necessitate the preparation of students for jobs that may not even yet exist.

Previous research of Hargittai (2010) indicates that individuals differ significantly in their digital abilities and activities they engage in online. She continues that digital abilities are linked to the frequency to which individuals engage in diverse types of online activities. According to Helsper (2012), access, skills, and positive attitudes toward digital devices and Internet are an important but not sufficient condition of beneficial use of digital technologies. Instead, more important factors are the different ways in which individuals engage with technologies, as different kinds of online activities are found to lead to different kinds of outcomes (e.g., Blank & Groselj 2014; van Deursen & Helsper 2015). Young people in the Nordic countries seem to be involved and interested in engaging with digital technology and Internet regardless of gender since, for example, the emergence of the social media has also attracted girls to active technology usage (e.g., Tømte 2011).

Helsper's (2012) corresponding fields model categorizes the technology usage based on its purpose and possible offline outcomes into the following key domains: Economic, cultural, social, and personal use. Economic use relates to commercial and information-related use and learning via digital resources, which increases individuals' abilities to gain benefits related to income or savings, employment, finances, and education. Cultural use relates to activities that increase individuals' feelings of belonging and identity, emerging as different forms of creative and productive activities related to virtual spaces of participatory cultures. Social use refers to connections to networks, which provide attention and social support for individuals. Forms of social use are, for example, online networks and group memberships built on common interests and digital communication. Personal use is associated with activities that increase resources for personality, aptitudes, and well-being, and manifest themselves as an online commitment to entertainment, self-expression, and health promotion actions. Domains are not exclusive, rather a particular use can be related to more than one domain—such as multiplayer game playing, which simultaneously represents both social (i.e., networks and group membership) and personal (i.e., entertainment and self-actualization) usage domains (Helsper 2012; van Deursen et al. 2017).

According to van Deursen and Helsper (2018), the role of online engagement together with digital skills is crucial for the benefits enabled by technology use in present societies and this is largely independent of the person's socioeconomic characteristics. Van Deursen et al. (2017) argue that it is generally assumed that some types of uses are more beneficial than others. They continue that more beneficial forms of technology use offer more possibilities and resources for individuals to move forward in career, work, education, and societal position than others. Digital inclusion policies and interventions have largely focused on economic uses, normatively valued as desirable and more profitable form of use, as the personal and social use of technologies has been assumed to be less beneficial (e.g., Blank & Groselj 2014; van Deursen & Helsper 2018). Van Deursen and Helsper (2018), however, came to an opposite view of the matter when they found that personal and social uses have the most collateral benefits to offer, as they increase overall well-being and participation in the information society.

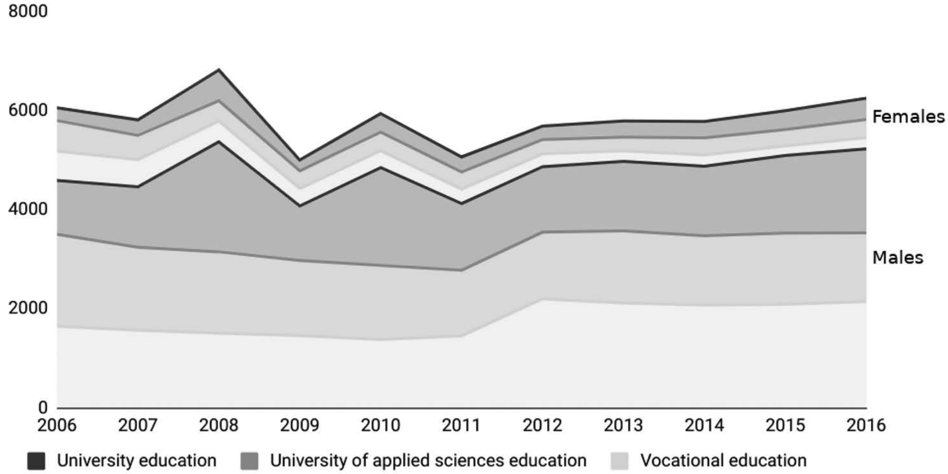
Inflows to the digital labor market

While in the case of general digital abilities the role of digital usage and engagement is essential, the skills required from digital workforce necessitate more formal learning due to the rise in the level of required competence in the field. The basic inflows in the ICT labor force come from ICT graduates from higher education, and in countries like Finland also from vocational schools of secondary education level. In fact, in Finland, there are multiple paths to gaining qualifications in the ICT field. For example, at the upper secondary level in vocational schools, students can choose the Natural Science track yielding qualifications in ICT or choose the Technology, communication, and transport track yielding qualifications in information and telecommunications technology. At the tertiary education level, the universities of applied sciences have degrees of Bachelor of Business Administration and Bachelor of Engineering majors in the ICT field. In addition, universities offer Bachelor's and Master's degrees in computer science, information systems, and engineering. These typical paths are complemented by several other kinds of training (MEC & FNAE 2017). In 2016, the ICT field was only the seventh most popular field of study and the main field for only about 9% of Finnish university students and only 18% of those students were females (OSF 2017).

The number of labor market entrants with a degree in the ICT field has not followed the trend of demand for ICT practitioners in the labor market in Europe; in fact, the number of ICT graduates has decreased since 2006 (Korte et al. 2014). As Figure 1 shows, the total number of ICT graduates in Finland has not fallen over the past decade, although it has not increased either. Due to the occupational restructuring referred in the Introduction, especially the proportion of university graduates has increased during the past decade. As a result of university degree reforms carried out during the year 2008, the number of graduates from universities suddenly, but transiently remarkably increased (Kyrö 2012). The number of university graduates increased strongly also in 2010, which was the end of the transition period of degree reform. On the basis of the official statistics of Finland (OSF 2017) about students and the qualifications of educational institutions, the gender gap in the ICT field also affects every educational level and form in Finland as shown in the Figure 1.

The European parliament reports (EP 2018) that only about 32% of current ICT workers in Europe are women. Globally, the existing gender gap has proved to be persistent; indeed, a low percentage of women majoring in computer science, computer engineering, and informatics in the Western countries not only has failed to increase but has even become lower (i.e., Vitores & Gil-Juárez 2012). Typical for European women working in the ICT sector is that they are more likely to have a higher education

Figure 1: Qualifications in ICT field in Finland during the years 2006 and 2016 by education form and gender (OSF 2017).



qualification than men (EIGE 2018). Similarly, results from Finland (Vuorinen-Lampila 2016) show that in the labor market more general, women tend to need a university degree in order to achieve equally favorable labor market status than men. Within the ICT field in Scandinavia, males reach higher positions more likely than women who more often remain in low-qualification jobs compared with men (Holth et al. 2013). This reflects the broader trend in the Nordic countries, where women continue to be disadvantaged in terms of wages and high status, despite the strong promotion of gender equality (Grönlund et al. 2017).

As shown in Figure 1, during the 10-year period of the exploration, also in Finland, the share of females has fallen among ICT graduates. In the near future, no major relief is expected in Finland, as career prospects are considered to be particularly traditional among 15-year-old Finns, as, based on the PISA report, boys are favoring technical fields and girls are preferring health care professions (OECD 2016). It should be noted that the ICT sector has not always been as male-dominated, rather the current state has evolved along with the increased status of the field. In the 1970s and 1980s, the proportion of women in the ICT sector was relatively high, as the status of the field was being low at the time. Since the emergence of the personal-computer industry and the Internet, low-skilled data entry roles were automated and men entered into the field in more higher status professions. At the same time, a male 'nerd' or 'hacker' became the stereotypical image of an ICT worker (EIGE 2018). The reasons for current under-representation of females in the ICT field are not only assumed in previous studies (Cheryan et al. 2016; EIGE 2018; EP 2012) to be rooted in women's lack of interest, skills and qualifications in the field, masculine organizational culture, and work-life imbalance, but also in these cultural stereotypes that do not offer attractive role models for girls or young women.

This study examines the digital skills of Finnish upper secondary school students and, in particular, their abilities in programming. The study also analyzes students' digital usage habits and their educational choices. The main focus of interest is in the students' future intentions to study or work in the ICT field and in which ways do the digital abilities and technology usage associate with these intentions. The research questions are the following:

(1) What are the levels of students' digital abilities in terms of medium- and content-related digital skills and programming skills?
(2) What kind are the digital technology usage habits of the students?
(3) Which variables associate with the digital skills and usage of the students?
(4) Which are the popular and unpopular fields of future education/occupation (i.e., future intentions) among students by gender and education?
(5) Which variables are the most prominent predictors of students' ICT intentions?

Methods

Participants

The data for this study were collected in Finland during 2017. Data consist of 3206 upper secondary school students' aged 15–22 years. The participants came from 43 municipalities (88 educational institutions) around the country. The municipalities were selected so that they geographically represented the Finnish municipalities. According to each of the six Regional State Administrative Agencies in Finland, small (<10,000 inhabitants), large (>100,000 inhabitants), and medium-sized municipalities were selected in terms of the proportion of the different sized municipalities in the region. Secondary schools themselves were able to decide on their participation in the research and on the participating student groups. Of participants, 69% were from general upper secondary schools, and 31% were from vocational upper secondary schools. As a whole, 52% of participants were female and 48% male students. Among the students from general upper secondary schools, female students were in the majority (female 64% and male 36%), whereas in the vocational schools, 55% of the students were male, and 45% were female. The data were collected as part of the project, Occupational restructuring challenges competencies, financed by the Strategic Research Council (SRC) at the Academy of Finland.

Measurement

Skills, usage, and future intentions were measured using an instrument called the ICT Skill Test developed in the Research Unit for the Sociology of Education (RUSE) at the University of Turku. The test started with questionnaires collecting first the students' background information (age and gender) and the form of education (general upper secondary school or vocational upper secondary school). The second questionnaire dealt with the participants' future intention: The field (ISCED-F) they desired to study or work in after graduating from their current educational plan. The third questionnaire was the digital usage habit questionnaire (usage activity, 0 = never, 1 = sometimes, 2 = weekly, 3 = daily, 4 = several hours per day, for the following specific purposes: Maintaining social relationships, communicating, running daily errands, following news, searching for information, creating digital content, sharing digital content, playing digital games, consuming digital entertainment, and studying using digital technology). Usage habit domains (economic, cultural, social, and personal use) (see Table 1) were formed, based on above-described Helsper's (2012) classification, by grouping them into the four usage domains, taking into account that certain uses associated with multiple domains. After this, the variable named versatility of daily use was calculated from the results of the questionnaire where the answer was 'daily' or 'several hours per day'.

Table 1 Items on the Usage Habit Questionnaire and their categorizations for usage domains.

Item	Economic use	Cultural use	Social use	Personal use
'I use digital technology (computers / laptops / tablets / smartphones) for: (0 = never, 1 = sometimes, 2 = weekly, 3 = daily, 4 = several hours a day)'				
Maintaining social relationships			×	
Commercial use	×			
Following current events	×			
Communication			×	
Game playing			×	×
Information seeking	×			
Digital entertainment				×
Creating digital content		×		
Sharing content online		×	×	
Learning	×			

The test was undertaken after the questionnaires. The test consists of 18 items (see Appendix 1), which are mainly based on the Finnish national core curricula for basic education. In the core curriculum, ICT competence is one of the seven transversal competencies integrated into all school subjects. The curricula aim to offer understanding of the basic operations and concepts of ICT, knowledge to use ICT in a responsible, safe, and ergonomic manner, and skills to use ICT as a tool in information management, creative work, social communication, and networking (FNBE 2016). The curriculum of the common basic education forms a basis for digital competence for all young people and further learning. That is why it also serves as a starting point for the ICT Skill Test.

Items were classified into medium- and content-related digital skills based on the framework of van Dijk and van Deursen (2014) described above. The following items were classified as medium-related skills: Basic operations, information networks, installations and updates, and functionalities of word processing, spreadsheet, and presentation software. In turn, the following items were seen as content-related skills: Information seeking, communication, video and audio processing, cloud services and publishing, image processing, social networking, information security, and software purchasing. Along with general medium- and content-related digital skills, the current study especially concentrates on those items related to programming (elementary programming, web programming, programming, and database operations). For analysis, the above-mentioned sum variables of digital skills were standardized with min-max normalization to range between 0 and 1, thus describing the average share of skill mastery from the potential maximum of the variable. Instead, the usage domain variables were left in their original scale ranging from 0 to 4, describing the average frequency of usages in particular domain.

Item analysis

Classical item analysis relies on test level (i.e., reliability and validity) and item-level statistic (e.g., item difficulty and discrimination power of the item). The coefficient alpha is the most common formula to measure internal consistency referring to the extent to which a test is a consistent measure of a specific concept described as the ratio of true-score variance to the observed-score variance (e.g., Kaplan & Saccuzzo 2017). Various threshold values for an acceptable coefficient have been presented, but these have been accused to be arbitrary and, according to Urbina (2014), there is no minimum threshold for a reliability coefficient that would be adequate for all purposes. However, basically, if all other things are equal, the higher the coefficient, the better. The Cronbach's alpha for the ICT Skill Test was 0.87, which indicates a relatively high measurement accuracy.

Validity refers to the extent to which the instrument measures what it is designed to measure. Content validity refers to the relevance of the instrument in relation to the concept to be measured. For content validity, there are no objective measures so it has to rely on the expertise of the content areas (Considine et al. 2005). In the development of the ICT Skill Test, several experts from the fields of educational and computer sciences, and user experience were involved in the development of the test contents. The relevance and the comprehensiveness of the content of the test was tested in preliminary studies involving both deliberately selected skilled and less skilled subjects. The pretesting confirmed that the test produced consistent results for skilled and less-skilled individuals.

Construct validity refers to the degree to which an instrument measures an intended theoretical concept and to a set of methods used to evaluate test items, such as item difficulty and item discrimination analysis (Kaplan & Saccuzzo 2017). Classical item difficulty refers to a proportion of participants who answer to the question correctly. High levels of correct answers (item difficulty values near 1) make the item appear easy and, conversely, low levels of correct answers (values near 0) indicate poor level of knowledge making the test item appear difficult or indicating inadequate instructions (e.g., Urbina 2014). In this study, to analyze item difficulty, an item difficulty index was used. It is considered to be more appropriate to be used with open-ended and construct-response items (Tiruneh et al. 2017), as it suits better for nondichotomous items and situations where the interest is not in the proportion of right answers, but rather on the level of participants' skills in particular item. The formula used to compute the item difficulty index (P) is:

$$P = \frac{\sim fX - nX_{\min}}{n\left(X_{\max} - X_{\min}\right)}$$

where $\sim fX$ is the total number of scores earned by all test-takers on an item, n is the number of test-takers, X_{min} is the smallest item score possible, and X_{max} is the highest item score possible. The item difficulty indexes for the ICT Skill Test ranged between 0.01 and 0.63. The difficulty indexes for other than programming-related items ranged between 0.21 and 0.63. These results indicate that the programming-related items, including elementary programming, turned out to be extremely hard for tested participants. Kaplan and Saccuzzo (2017) argue that for most tests, items with difficulty range between 0.3 and 0.7 tend to maximize information about the differences among participants. They remind that a desirable level of difficulty depends on the purpose of the test.

As the purpose of the ICT Skill Test is not to measure age-related skills in a particular school subject, but to meet the skills requirements in real life which are not age-related, it is perfectly acceptable that the item difficulty levels of the programming-related items remain low among the students.

The item discrimination is a basic measure of the validity of an item. It is defined as the ability of an item to discriminate (or differentiate) between high and low achievers. The item discrimination index ranges from 0 to 1 and the higher the value, the better the discrimination power the item possesses (Adams & Wieman 2011; Urbina 2014). The formula used to compute the discrimination index (D) is:

$$D = P_U - P_L$$

where P_U and P_L are the difficulty indexes for the highest performing (U) and lowest performing (L) groups. There is no common agreement about what percentage to use to determine these groups. The optimum percentage has been stated to be approximately 27%, but anything up to 50% has been mentioned in the literature (Adams & Wieman 2011). In this study, the threshold of 27% was used to divide the highest and lowest performing groups. The item discrimination indexes for the ICT Skill Test ranged between 0.04 and 0.99, indicating problems with programming-related items, which were already known to be extremely challenging for the participants. For other items, discrimination indexes ranged between 0.30 and 0.99, indicating a strong ability to discriminate between the skilled and unskilled participants.

Item discrimination can also be measured using the item-total correlation that is the Pearson's product moment correlation coefficient between an item and the scale total calculated from the remaining items. The result of item-total correlation indicates whether an item fails to correlate with the total score; values near 0 mean that the items are likely to be extremely easy or difficult, ambiguous, or that this item is not measuring the same construct being measured by the other items. The extremely high values are also unfavorable, as an item total correlation near 1 can be considered redundant (Considine et al. 2005; Kaplan & Saccuzzo 2017). The item-total correlation values for the ICT Skill Test ranged satisfyingly between 0.21 and 0.66 and achieved statistical significance ($p < 0.001$). Altogether, the above values of reliability and validity confirm the perceptions of the satisfactory quality of the applied instrument, even though programming-related items were found to be challenging for the participants.

Analysis

The levels of digital abilities and usage were examined via means and standard deviations, and the relationships between the variables were analyzed utilizing the Pearson's correlation coefficient that is a measure for linear relationship between two variables (e.g., Rodgers & Nicewander 2003). Seeking to scrutinize the popularity of future fields of education/occupation, a visualization technique called Sankey diagram was utilized. Sankey diagrams present quantitative information about flows, relationships, and transformations. They are directed, weighted graphs with 2–n nodes, wherein the sum of the incoming weights for each node is equal to its outgoing weights (Riehmann et al. 2005; Schmidt 2008). In the current study, the Sankey diagram was used particularly to represent the relationships and connections between the examined variables. Because visualization does not adequately take into account the differences in size of the groups to be compared, the Chi-square test was used for more comprehensive analysis.

Logistic regression was used to assess the effects of independent factors (age, gender, education form, digital abilities, and usage) on students' ICT intentions, which appears as a dichotomous variable in the data. According to Peng and So (2002), logistic regression is well suited for examining the relationships between a dichotomous or a qualitative dependent variable and one or more independent predictor variables. There are several possibilities to measure the difference between the observed and fitted values, that is, the goodness of fit, in the case of logistic regression. In this study, the overall model significance for the logistic regression is examined using the Chi-square test of model coefficients. Nagelkerke *R*-squared is used to examine the percentage of variance accounted for by the independent variables. The Hosmer-Lemeshow test is also a common statistical test for goodness of fit for logistic regression models. The test measures whether the observed values match the expected values in the subgroups of the model population; the test value 1 indicates perfect fit (Hosmer & Lemeshow 2000). Mood (2010) has notified that because the coefficients of logistic regression depend both on effect size and the magnitude of undetected heterogeneity, one cannot compare coefficients between models or samples as is usually done with linear regression models. In this study, logistic regression was therefore not used to compare different models, but only aimed at detecting which independent variables explain the variance of dependent variable.

Results

Digital abilities and technology usage

As the Table 2 summarizes, on average, students succeeded in 38% of medium-related items and 42% of content-related items of the ICT Skill Test. Overall, the performance in the programming items was low; on average, students reached just 7% of scores available in programming-related items. The economic use was the most popular usage domain among upper secondary education students. This is most probably due to the fact that information seeking and using devices for learning is abundant among students in the secondary education level. The second most popular usage domain was personal use that included leisure time activities like computer gaming or listening to music or watching movies and TV series online. The social use was the third most popular usage domain including social interaction related Internet activities. The cultural use domain proved to be the least popular usage domain among students referring to activities like creating and sharing one's own digital content. On the basis of the usage habit questionnaire, on average, the students responded using digital technologies for four purposes (out of 10) on a daily basis. The use of digital technologies was found to be an essential part of the daily life of young people in Finland, as only 4% of students did not report using digital technology for any purpose on a daily basis.

Table 2 also represents the correlations between variables. It can be noticed that one type of digital skill strongly associates with other types of digital skills. Especially the correlation between medium-related and content-related skills was strong (r = 0.72). Also, programming skills correlated positively with both medium (r = 0.45) and

Table 2 Descriptive statistics and correlations (***N*** = 3206).

Variable	M (SD)	1	2	3	4	5	6	7	8	9	10	11
Age	16.7 (1.23)	1										
Gender (0 = female)	0.48 (0.49)	0.01	1									
Education form (0 = Guss)	0.31 (0.46)	0.32***	0.17***	1								
Medium-related skills	0.38 (0.21)	0.09***	0.10***	–0.08***	1							
Content-related skills	0.42 (0.19)	0.09***	0.01	–0.13***	0.72***	1						
Programming skills	0.07 (0.11)	0.03	0.18***	0.01	0.45***	0.51***	1					
Economic use	1.95 (0.59)	0.15***	-0.07***	–0.11***	0.17***	0.21***	0.06***	1				
Cultural use	0.92 (0.61)	0.02	-0.04	–0.08***	0.09***	0.11***	0.09***	0.36***	1			
Social use	1.88 (0.44)	-0.01	0.03	–0.07***	0.09***	0.12***	0.03	0.40***	0.42***	1		
Personal use	1.92 (0.61)	-0.02	0.21***	0.03	0.13***	0.11***	0.10***	0.25***	0.20***	0.50***	1	
Versatility of use	4.12 (1.96)	0.05***	0.05***	–0.05***	0.18***	0.18***	0.09***	0.72***	0.48***	0.68***	0.55***	1

M = mean; *SD* = standard deviation; *Guss* = general upper secondary school; ***$p < 0.001$.

content-related ($r = 0.51$) digital skills. Among background variables, age had only negligible positive association with medium- ($r = 0.09$) and content-related ($r = 0.09$) skills, but no significant association with programming skills. Being a student in general upper secondary school had a slightly positive association with both medium- ($r = 0.08$) and content-related ($r = 0.13$) skills, while there was no significant relationship between the form of education and programming skills. Instead, gender had an association with programming skills ($r = 0.18$), as male students succeeded better in programming tasks than female ones. Being a male was also slightly associated with medium-related digital skills ($r = 0.10$).

When examining usage habits, it was found that female students were a little more inclined to use technology for an economic purpose ($r = -0.07$) than males, while male students were more likely to be active in the personal use ($r = 0.21$) domain than females. Like digital skills, digital usage was also found to be cumulative, as usage domains correlated clearly with each other. In particular, economic and social use strongly correlated with versatility of daily use ($r = 0.72$ and $r = 0.68$). In general, more active digital usage was also associated with increased digital skills; medium- and content-related skills were most clearly associated with economic use ($r = 0.17$ and $r = 0.21$) and versatility of daily use ($r = 0.18$ and $r = 0.18$), whereas programming skills were only slightly positively associated with usage domains and versatility of use in general, but still relatively more with cultural ($r = 0.09$) and personal use ($r = 0.10$) than social (0.03) and economic (0.06) use.

Future intentions

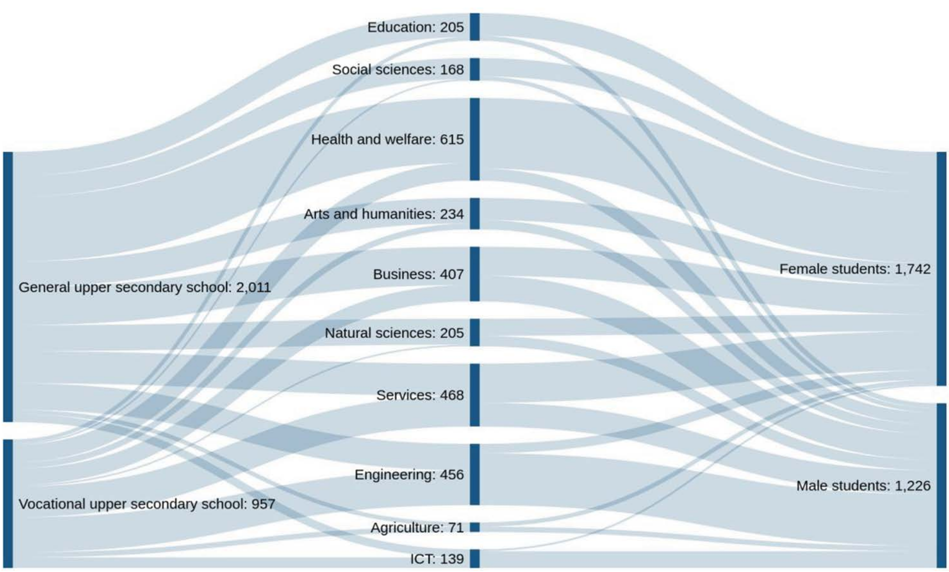
Figure 2 represents the popularity of future field of education/occupation by gender and current educational choice. The most popular field of future education/occupation among female students was health and welfare, which was a choice of 28% of female students. The second most popular field among female students was services (16%) and the field of business, administration, and law ranked third (12%). Female students also favored education (9%) and arts and humanities (9%), and to some extent social sciences, journalism and information (7%) and natural sciences, mathematics and statistics (7%). The least popular fields among female students were ICT (1%), agriculture, forestry, fisheries, and veterinary (2%), and engineering, manufacturing, and construction (4%).

By contrast, the most popular field among male students turned out to be engineering, manufacturing, and construction, which was a choice of 29% of males. The second most popular field among male students was business, administration, and law (14%), whereas the third most popular field was services (13%). Also, the ICT field attracted male students (9%). Health and welfare (7%), art and humanities (6%), and natural sciences, mathematics, and statistics (5%) ranked after the ICT field in popularity among male students. Social sciences, journalism, and information was the least popular field of future education/occupation for males (2%) followed by agriculture, forestry, fisheries and veterinary (3%), and education (3%).

The most equal gender distribution seems to be found in the business, administrative, and legal field, as the share of genders was quite even. However, the visual image shown in Figure 2 is misleading to some extent unless both the observed values and the expected values are taken into account. The Chi-square test revealed a significant difference between genders ($X^2 = 5{,}157$, $df = 1$, $p = 0.023$), and, in fact, the business sector was more popular among male than female students. When the number of female and male students in the sample in question were considered, it was found that the most gender-independent choice was the field of natural sciences, mathematics, and statistics ($X^2 = 1{,}392$, $df = 1$, $p = 0.238$). Instead, the male-dominated fields of ICT ($X^2 = 137{,}122$, $df = 1$, $p < 0.001$) and engineering, manufacturing, and construction ($X^2 = 397{,}297$, $df = 1$, $p < 0.001$) were the most gendered fields of future intentions, followed by the most female-dominated fields; education ($X^2 = 51{,}509$, $df = 1$, $p < 0.001$) and social sciences, journalism, and information ($X^2 = 38{,}291$, $df = 1$, $p < 0.001$).

Similarly, based on Figure 2, the field of services seemed to be popular among both general and vocational upper secondary school students. However, a more in-depth examination revealed that when taking into account the number of students in the sample, students from vocational upper secondary schools were more likely to choose the service sector ($X^2 = 78{,}734$, $df = 1$, $p < 0.001$) than students from general upper secondary schools. Instead, the form of education had no significant effect on the intentions to seek to the field of business in the future ($X^2 = 408$, $df = 1$, $p = 0.523$). The fields of natural sciences, mathematics, and statistics ($X^2 = 66{,}140$, $df = 1$, $p < 0.001$), social sciences, journalism, and information ($X^2 = 48{,}264$, $df = 1$, $p < 0.001$), and health and welfare ($X^2 = 34{,}545$, $df = 1$, $p < 0.001$) were most likely favored by students from general upper secondary school, whereas the intentions to study or work in the fields of ICT ($X^2 = 43{,}858$, $df = 1$, $p < 0.001$) or engineering, manufacturing, and construction ($X^2 = 160{,}007$, $df = 1$, $p < 0.001$) were dominated by students from vocational upper secondary schools.

Figure 2: Sankey diagram of the popularity of future field of education/occupation by gender and current educational choice.



The logistic regression was used to analyze the predictors of students' ICT intentions (Table 3). The odds of intentions to study or work in the ICT field in the future for males was found to be over seven times higher than the odds for females (odds ratio, *OR* = 7.26, $p < 0.001$). Likewise, the odds of continuing in the ICT field in the future for vocational upper secondary school students was found to be somewhat larger than the odds of general upper secondary school students (*OR* = 0.411, $p < 0.001$). Instead, age did not have a significant impact on ICT intentions. Among digital abilities, especially higher levels of medium-related skills predicted students' ICT intentions, as one-point growth in medium-related skills lead to an increase in odds of more than five times (*OR* = 5.90, $p < 0.001$). Programming skills had a similar effect, albeit to a much lesser extent (*OR* = 1.525, $p < 0.001$). Instead, content-related skills did not have an impact on students' ICT intentions. The role of technology usage habits proved to be less relevant compared to the background variables and the digital abilities of students. However, the abundant use of technology in the personal use domain made an exception; an active online engagement on the domain that includes personal enjoyment and expression, being more typical for males, increased remarkably the likelihood of students heading for the ICT field (*OR* = 14.315, $p < 0.01$). The logistic regression model was significant, $\chi^2 = 310.901$, $df = 11$, $p < 0.001$, accounting for 31% of the variance (Nagelkerke R^2) of dependent variable. A Homer-Lemeshow test was used to assess the goodness of fit of the logistic model. The test yielded a χ^2 of 5.108 with $df = 8$ and p-value of 0.747 suggesting an adequate overall fit of the model (see Table 3).

Table 3 Logistic regression model predicting the students' ICT intentions.

							95% CI	
Independent variables	**B**	**SE**	**Wald**	***df***	***p***	***OR***	**Lower**	**Upper**
Age	0.031	0.081	0.129	1	0.699	1.032	0.880	1.209
Gender (0 = female)	1.982	0.297	44.620	1	0.000***	7.260	4.058	12.987
Education (0 = general)	0.888	0.209	18.067	1	0.000***	0.411	0.273	0.620
Medium-related skills	1.775	0.329	29.055	1	0.000***	5.900	3.094	11.249
Content-related skills	–0.741	0.418	3.136	1	0.077	0.477	0.210	1.082
Programming skills	0.422	0.088	23.053	1	0.000***	1.525	1.284	1.811
Economic use	–0.150	0.993	0.023	1	0.880	0.861	0.123	6.025
Cultural use	1.114	0.695	2.570	1	0.109	3.407	0.780	11.893
Social use	0.641	1.219	0.277	1	0.599	1.899	0.174	20.703
Personal use	2.661	0.872	9.315	1	0.002**	14.315	2.592	79.073
Versatility of daily use	–0.869	1.083	0.643	1	0.422	0.419	0.050	3.505
N	3135							
Model Chi-square	310.901			11	0.000***			
Hosmer and Lemeshow test	5.108			8	0.747			
Nagelkerke R^2	0.310							

B = unstandardized beta; *SE* = the standard error for the unstandardized beta; *df* = degrees of freedom; *OR* = odds ratio; *CI* = confidence interval; *** $p < 0.001$; ** $p < 0.01$.

Discussion

Students' overall performance in test items requiring medium- and content-related digital skills remained, on average, rather low. Especially the participated students struggled with the items that required medium-related skills. This is probably due to the ease of use of current digital devices, as their use does not require advanced technology abilities. The level of programming skills of the students was found to be very low and only a few students succeeded in these tasks. This is understandable since programming was not part of the curricula at the time the tested students were pupils in basic education, and thus, the students were generally not expected to have these skills. The purpose of including the programming tasks in the ICT Skill Test was to find out whether or not there were students who possess these kinds of preliminary information needed in studies in the ICT field due to their own interest toward the subject. Instead, the new national core curriculum for basic education in Finland (in use since 2016) strives to offer early experiences with programming, algorithmic thinking, and problem solving to every young girl and boy during the 9-year basic education (FNBE 2016). This is undoubtedly a positive goal. Unfortunately, the first students, taught with the new curricula, will graduate from Finnish upper secondary schools at the earliest in year 2028 – that is a long time for the current labor market to wait for youngsters who have benefited from these early experiences.

On the basis if the results, digital abilities were found to accumulate, as both medium- and content-related skills and programming skills strongly correlated with each other. Digital abilities were found to associate especially with versatile use of technologies for different purposes on a daily basis and with frequent use of technologies for economic purposes such as for learning or information-seeking activities. Similarly, in previous studies, the positive role of young people's digital technology usage for their digital abilities has been identified (Hatlevik et al. 2018; Kolko et al. 2013). Like digital skills, digital usage was also found to be cumulative; the active use in one usage domain correlated with increased activity in other domains as well. It can be considered evident that digital skills and digital usage are intertwined and necessitating one another; skills enable usage and, on the other hand, usage offers the opportunity to practice and acquire new skills.

One key finding in this study is that students' educational/occupational intentions appear to be strongly gendered choices. The finding resonates with the concept of horizontal segregation that refers to the tendency of genders to concentrate in gender-specific fields of education and occupations (Triventi et al. 2015). According to Triventi et al. (2015), high occupational specificity, which is typical in educational systems with a separation between vocational and general forms of education, links education and occupations strongly together, and increases the likelihood of horizontal gender differentiation. Such an education system is not only typical, for example, for Germany but also for Finland, which makes the observation of genderedness of the students' future intentions at least to some extent expected. On the basis of the results of this study, especially intentions to apply to the ICT field were considered to be strongly gendered, as just about 1% of female students announced their intention to enter the field in future, while 9% of males reported the same.

On the basis of the results of this study, the students' ICT intentions were, in addition to male dominance, largely explained by digital abilities, especially those requiring more technical knowledge; the likelihood of students choosing the ICT field increased significantly along with higher competence in both medium-related skills and programming skills. As a consequence, it can be stated that the digital competence of students should be strengthened if more ICT applicants are sought. This is especially important when pursuing female applicants, as the technical skills of females have been found weaker than males also in several previous studies (e.g., Kaarakainen et al. 2018; van Deursen & van Dijk 2015), and low technical self-efficacy has been found to be a major barrier on females' access to STEM fields (Cheryan et al. 2016). In this respect, the results of this study emphasize the need to influence both on technical self-efficacy and on young girls' interests toward the ICT field. On this context, Cheryan et al. (2016) have emphasized the role of offering early experiences and female role models for young girls when targeting to increase women's participation in computer science and engineering.

However, this study is not able to answer why the future intentions of Finnish young people are so strongly associated with gender and seem to reproduce rather traditional gender expectations. In future research, it would be worth exploring more precisely at what age and as a result of which kind of social processes such preferences evolve. This necessitates exploring the significance of digital engagement and further digital education and labor for young people themselves and the importance of such aspects in the social relations surrounding them. The need of this kind of research is underlined by the fact that there is no tremendous difference between the genders in the amount of or interest toward digital engagement per se. Knowledge of the processes that produce differentiative gendered preferences would contribute in finding effective ways to influence the issue. More generally, the results of current study highlight a broader dissonance between the labor market growth expectations and the popularity of the ICT field among young people in Finland. As the future orientation questionnaire revealed, only fewer than 5% of students in upper secondary education are planning to study or work in the ICT field in the future. It is to be noted that excluding the agriculture, forestry, fisheries, and veterinary field, all other fields of education/occupation seem to attract young people more than the ICT field does. Interventions should be therefore directed not only at girls but also at all young people if there are aims to increase the attractiveness of the ICT field as a future career.

According to the results of this study, digital skills proved to be at least to some extent better among general upper secondary school students than among vocational upper secondary school students. The same kind of finding has also been made in the previous studies (e.g., Calvani et al. 2010; Hatlevik & Christophersen 2013). As the role of technical expertise was identified as a key element for the students' ICT intentions, it could have been expected that the ICT field would have been popular particularly among students from general upper secondary schools. However, this was not the case; instead, the students from general upper secondary schools were a minority among those who indicated their willingness to apply to the ICT field in future. Therefore, the results seem to require increased knowledge of opportunities of the ICT field professions, especially for general upper secondary school students.

Even though the current expectations in the ICT field are positive and indeed massive growth in employment of ICT professionals is predicted, it does not guarantee the actualization of these opportunities. Like Korte et al. (2014) have warned, if the currently open positions cannot be filled and a skills shortage remains year after year, the potential for growth will be lost. In any case, the current skills shortage in the ICT field cannot be solved solely with new ICT graduates; they are simply too few in numbers. Even the potential success in raising the popularity of the field among basic and secondary education students could not quickly affect the number of higher education graduates in the field. Rather the current situation calls for various kinds of updating training and retraining, continuous professional education, and lifelong learning. In addition, the shortage calls for the development of curricula at every level of education and across all education fields to meet the demands of the present society and demands of both the digital education and workforce. Nevertheless, there is a need for effective actions that can increase the popularity of the ICT field among young people in order to increase the workforce in the field and to reduce the gender imbalance in both the digital education and labor market.

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Appendix 1. The test items, description and the results of item analysis of the ICT skill test.

Item	Description	*p*	*D*	*r*
Medium-related skills				
Basic operations	Participants have to pair a keyboard shortcut with a correct action and choose a correct type of computer memory for present education situation.	0.21	0.61	0.44
Installation and updates	In the first step, participants choose whether a statement is about an installation or an upgrade and in the second step, they choose whether a statement is related to an update or an upgrade.	0.49	0.85	0.58
Information networks	Participants are given four network usage scenarios and have to pair them with correct data transmission technologies and then match correct descriptions of computer network-related concepts.	0.18	0.47	0.36
Word processing	Participants are asked to edit (bold, italicize, underline, and highlight) a given sample text.	0.54	0.99	0.48
Spreadsheets	Participants are asked to fill a spreadsheet table with given information, bold a header row, and sort the table in ascending order.	0.29	0.73	0.52
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.	0.31	0.80	0.52
Content-related skills				
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.	0.41	0.64	0.60
Communications	Participants have to fill in the receiver fields, carbon copy, and blind carbon copy) of an email and add an attachment according to instructions, and identify the types of information that can be used to identify Internet users.	0.46	0.80	0.66
Information security	Participants have to choose correct statements for secure network communications and choose from alternatives those that are related to the information security of computers in an Internet cafe abroad.	0.43	0.74	0.65
Image processing	Participants have to select correct image processing tools for cropping an image and make the person appearing in the image unrecognizable. Afterwards, participants have to choose correct image processing using related statements from given options and choosing the correct file formats for vector graphics.	0.33	0.58	0.59
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?'.	0.44	0.82	0.64

(*Continued*)

Appendix 1. (*Continued*)

Item	**Description**	***p***	***D***	***r***
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 one 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 the video does not circulate to the rest of the Internet for outsiders to see [...]?'	0.44	0.90	0.58
Software purchasing	Participants have to choose which matters need to be considered when evaluating the information security of mobile applications and also choose the correct definition of personal data protection from four alternatives.	0.22	0.52	0.48
Information seeking	Participants have four cases where they have to choose a correct source/channel, out of three, on where to further seek information on a given topic. After this, they are presented with list of search engine results and are asked to choose two relevant and reliable results related to given scenario.	0.63	0.55	0.39
Programming skills:				
Elementary programming	Participants have to write, per instructions (L = 90 degrees to the left, F = one step forward...), a maze traversing script that leads from the starting point to the end. After this, they are presented a short pseudo-code and they have to write the value of a particular variable after the given code has completed.	0.09	0.30	0.43
Database operations	Participants have to form an SQL-query, based on given instructions and a simple database diagram, then choose the right definition for the concept 'NoSQL database'.	0.05	0.17	0.21
Web programming	Participants are given three files (HTML, CSS and JavaScript) to use to create a website and the view generated by these files. Participants then answer four multiple choice questions to edit the simple web page view and the dependencies between these given files.	0.08	0.28	0.26
Programming	The programming task requires the participants to place lines of Java code in the correct places based on given comment sections.	0.01	0.04	0.25