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Multilevel analysis of the educational use of technology: Quantity and versatility of digital technology usage in Finnish basic education schools

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Abstract

The adoption of technology in teaching has been identified to relate to various factors from attitudes and self-efficacy to subjective norms and digital references. The aim of this study is to broaden the perspective to hierarchical grouping effects. Multilevel modelling of the study utilizes the data of 2355 Finnish basic education teachers. The results show that, before the coronavirus pandemic, Finnish teachers used digital devices in teaching at least once a week, on average, and many times on a daily basis, varying according to the subject being taught. The variation in teachers' technology usage occurs mainly at the individual level, with a small proportion between schools; higher-level hierarchies proved redundant in the context of Finland. At the teacher level, digital skills, age, and digital self-efficacy increase technology usage in teaching. At the end, the significance and limitations of the research and the direction of future research in the post-pandemic era are discussed.

KEYWORDS

basic education, grouping effects, multilevel analysis, schools, teachers, technology usage

1 | INTRODUCTION

The rapid development of digital technologies and the large-scale digitalization of societies are impacting education at all levels, from governance to pedagogical practices. Education policies aimed at embedding digital technology into schools are justified by various reasons. First, digital technologies hold the promise of enhancing the traditional learning experience and are expected to solve persistent problems such as non-engagement or inequality in educational opportunities. Second, digital technologies are seen as enhancing global equality, development opportunities, and economic growth by presenting these technologies as suppliers of material, cultural, and cognitive resources, which improve participation, networking, productivity, and even democracy. On the other hand, the widespread presence of technology both at work or in school and leisure time in everyday life creates demand for digitally skilled citizens. In this context, the digitalization of education plays a role in balancing the opportunities and risks associated with inequalities between differently skilled people in modern society. Finally, education policy can also be employed for regulation, control, and surveillance, for example, to reduce administrative or other costs or to increase datafied learning optimization and decision making through digitalization (see, e.g., van Deursen & van Dijk, 2016; OECD, 2015; Selwyn et al., 2020; UN, 2005; UNESCO, 2017; WB, 2003).

Alongside education policy, at the level of pedagogical activity, technological developments per se and the education technology products they have enabled have largely shaped the landscape of teaching practices in recent decades. Computer assisted learning has existed since the 1960s and 1970s (e.g., Alpert & Bitzer, 1970), but its widespread adoption in education dates back to the spread of the Internet in the 1990s. According to Conole (2017), web technology has been a key transformative force in education: at the turn of the 21st century, multimedia materials, stand-alone software, and learning management systems made possible by early technology began to coexist with novel gaming technologies as well as with interactive and social learning applications. Since then, especially over the last decade, the education technology industry has shifted from the simple electrification of learning content to complex personalized digital learning environments that adapt to learner activities and provide real-time analytics about learning for teachers and learners (e.g., Williamson, 2017). Concurrently, with the intense spread of mobile devices, it has become possible to obtain information and communicate without time and space restrictions, and familiar applications from consumer use have spread to schools with students' own devices (e.g., Conole, 2017). The latter has also reduced dependence on the devices and resources provided by educational institutions.

In many technologically advanced countries, it has been said that education is on the verge of change as a result of novel technology for quite some time (e.g., Laurillard, 2008). A few years ago, the Organisation for Economic Co-operation and Development (OECD) (2015) stated that schools around the world have fallen far behind the promise of technology, illustrating the fact that, for a long time, the digitalization of education did not seem to make much progress and the benefits fell far short of the high hopes. The recent Covid-19 pandemic accelerated the adoption of digital learning tools as schooling switched to distance learning in the spring of 2020 in many countries. This large-scale transition is expected to have a significant impact on the digitalization of the education sector, the consequences of which can be observed in the coming years.

The aim of this study is to provide a multilevel perspective on the teachers' use of digital technology in teaching in the context of highly technologicalized societies. With Finnish basic education teachers providing a practical example of such a situation, this study examines the teachers' use of digital technology in their teaching. The study aims to describe the pre-pandemic situation from which distance learning was introduced during the pandemic in the spring of 2020, providing a point of reference for the post-pandemic examination and reflection.

2 | DIGITAL TECHNOLOGIES IN EDUCATION POLICY AND TEACHING

The policy trend promoted by major international organizations such as the OECD, The United Nations, and the World Bank has required the improvement of human capital and economic competitiveness through education, especially since the 1990s, highlighting the benefits of technological developments for these efforts (e.g., OECD, 1996; UN, 2005; WP, 2003). In particular, information technology and related skills have been widely considered as key factors in the success of harnessing the evolving information economy (see, e.g., Saari & Säntti, 2017).

Global differentiation in the adoption of technology in schools has been a major challenge. Several challenges, such as cost, lack of teacher training, and lack of necessary infrastructure, but also government policies and curricula incompatible with technology adoption, have hindered the successful adoption of education technology in developing countries (Ejiaku, 2014; Ezumah, 2020). At the same time, the uptake of digital technology in education in developed countries has made accelerating progress, although not at the same pace between different countries and regions even in the West. One recent trend in Western countries is the advancement of so-called digital governance, which is closely related to the new wave of education standardization supported by datafication, exemplified by the shift to measurability (focus on "learning outcomes") or transparency in education practice. This phenomenon is particularly a product of a typical European space of education, linked to the *Europeanization of education*, in which digitalization plays a significant role (Landri, 2018).

Within this context, the need to accelerate the digitalization of the education sector has received a lot of attention in public debate in Finland as well, especially with the digitalization of education playing a significant role in the Finnish government's strategic program in 2015 (Prime Minister's Office, 2015). In the program, the digital learning environments and new pedagogical approaches were expected to promote future skills, increase lifelong learning, reduce drop-out rates, and increase opportunities of renewal in Finnish society. At the same time, the national basic education curriculum reform increased the role of information technology and multi-literacy skills in educational goals (FNBE, 2016). In Finland, all schools at the basic education level follow the national core curriculum and are publicly funded, with responsibilities shared between the state and the municipalities. The Finnish education system is rather decentralized: education providers (municipalities) are responsible for teaching arrangements and quality of education, within which schools offer services in accordance with their own administration and vision insofar as the functions determined by law are carried out. Teachers have pedagogical autonomy in teaching methods as well as in relation to textbooks and other materials (see, e.g., MINEDU, 2018). In these circumstances, especially at the political level, there has been a clear desire to promote the digitalization of education over the last decade. As one of its manifestations, the rhetoric of the "digital leap" was adopted in the language of the Finnish education policy, thus leading to a rapid modernization of information technology infrastructure and related teaching practices in schools (e.g., Saari & Säntti, 2017).

In the context of education, digital technology is seen as both an object of learning and a tool for learning. Tondeur et al. (2007) have identified three types of digital technology-related goals in education: acquiring basic digital skills, utilizing technology as an information tool, and making use of technology as a learning tool. The goal of acquiring basic digital skills identifies technology usage as a separate school subject, while using technology in education emphasizes the role of technology as a learning tool. When digital devices are seen as an information tool, the emphasis is on the interaction between students and the subject-domain content. In turn, when digital technology is used as a learning tool, students use devices to practice knowledge and skills (Tondeur et al., 2007). In the renewed Finnish national core curriculum for basic education (see, FNBE, 2016), information technology skills are seen as integral to civic skills, or the so-called transversal skills, being integrated and applied in all school subjects without as a separate school subject. In practice, the aim is to provide an understanding of basic functions and concepts of how to use technology in a responsible, safe, and ergonomic manner and of skills to use digital technology as a tool in information management, creative work, social communication, and networking.

When examining the broader situation in Europe, according to a survey of teachers in 31 European countries, the most common education technology activity in 2011 was related to lesson preparation (e.g., browsing the Internet to collect material and search for information or preparing tasks and presentations). In contrast, teachers rarely went online to communicate with parents or post homework, nor did they use technology to assess students. Technology-based activities were most often used by teachers in Denmark, Estonia, Latvia, Lithuania, and Norway. However, European students made only little use of their school's digital tools, such as online textbooks, exercise software, broadcasting, data-logging tools, simulations, or learning games (EC, 2013). Correspondingly, more recent results from Hinostroza et al. (2016) show that teachers use technology inside the classroom mainly to present lessons and outside the classroom to search for materials, perform administrative tasks, communicate with students, and design assignments, thus continuing to emphasize rather teacher-centred practices in technology usage.

By focusing more closely on Finland, the results of the PISA 2018 study (OECD, 2019) show that 99.5% of all participating students (aged 15–16) in Finland had access to the Internet at home, and the most commonly used device was a laptop. Similarly, according to the EU Kids Online 2020 survey (Smahel et al., 2020), 97% of Finnish children aged 9–16 have access to a smartphone, usually their own. According to the same survey, the use of digital devices increases as children grow older, and as they reach lower secondary school, they all typically use technology in one way or another on a daily basis. Based on the PISA 2018 study (OECD, 2019), 15-year-old Finnish students use the Internet for more than an hour at school and almost 3 h at home on a typical weekday. Compared to the 2012 survey (OECD, 2015, 2019), Internet use by young Finns has increased both at home and at school, although most growth has taken place at home. Evidently, children and young people in Finland use digital technology considerably more at home than at school, and the digital activity of Finnish students has increased, especially with the digitalization of homes and leisure time.

Simultaneously, with the abundant daily use of digital devices by young people, it is typical for Finland that the use of technology in school assignments has remained relatively low. According to the EU Kids Online study (Smahel et al., 2020), Finnish children use the Internet for schoolwork significantly less than their coevals in comparison countries. More specifically, the PISA 2012 study (OECD, 2015) revealed that only less than one-fifth of students in Finland had used computers for mathematics lessons in the previous month, while the corresponding proportion in other Nordic countries was over 70% in Norway and almost 60% in Denmark. Recent national research (Tanhua-Piiroinen et al., 2020) confirms that the trend has remained the same; although the use of digital tools is gradually increasing in teaching, there has been no significant transition towards digitality in learning situations in Finnish basic education.

3 | FACTORS RELATED TO TECHNOLOGY USAGE IN CLASSROOMS

Overall, in the PISA 2012 study (OECD, 2015), the use of technology in schools was mostly dependent on teacher-level factors rather than on school-level policies. The report assumes that school-level policies may address more qualitative aspects (e.g., ways of using technology) than quantitative aspects (e.g., whether digital devices should be used in teaching at all). In contrast, other policies, such as the national curriculum, seem to play a more important role in furthering or discouraging the integration of digital technologies into education. The report (see, OECD, 2015) also pointed out that teachers who were more inclined towards student-oriented teaching methods (e.g., group work and individualized learning) were more willing to integrate digital technology into their teaching.

When examining teachers' personal characteristics, several studies indicate that male teachers use digital technology in the classroom more frequently than female teachers (e.g., Gil-Flores et al., 2017; Umar & Yusoff, 2014). Similarly, digital self-efficacy has been found to be higher among male teachers than female teachers (e.g., Gudmundsdottir & Hatlevik, 2018; Nikolopoulou & Gialamas, 2016; Umar & Yusoff, 2014), thereby presumably reducing the use of technology among female teachers. In regard to age, younger teachers use technology in education more frequently than older teachers, and they face fewer problems in using technology for teaching than their older colleagues (e.g., Scherer et al., 2015; Umar & Yusoff, 2014). However, the study of Gudmundsdottir and Hatlevik (2018) recalls that newly qualified teachers have both positive and negative experiences of using digital technologies in their teaching. Therefore, the digitalization of education will not inevitably progress with the new generations of teachers.

On the other hand, age is related to cumulative experiences of both the teaching profession and the use of technology per se, with age having different effects on the use of technology in teaching. Gil-Flores et al. (2017), for example, found that professional experience had a negative effect on teachers' technology use: as the years of teaching experience increased, the digital technology use in teaching diminished. Instead of teaching experience, teachers' experience with computers for teaching purposes strongly predicted their future use of technology in teaching situations (Drossel et al., 2017). Therefore, the age of teachers does not in itself determine the use of technology in teaching but rather the accumulated experience of (successful) technology use in teaching and a positive perception of its effects.

In previous studies, teachers' digital competence has been found to help them adopt new pedagogical practices and integrate technology in their teaching: teachers with advanced digital skills are likely to use digital technologies more frequently in their instruction than those with weaker skills (e.g., Az-eddine & Hicham, 2017; Hatlevik, 2017). Several previous studies indicate that teachers' digital self-efficacy has a positive association with their information technology usage (or at least the usage intention) in instructional practices (e.g., Drossel et al., 2017; Hatlevik, 2017; Hatlevik & Hatlevik, 2018; Kreijns et al., 2013; Nikolopoulou & Gialamas, 2016; Scherer et al., 2015). Therefore, it can be stated that digital technologies are used in education more often and in more versatile ways when teachers have not only the necessary digital skills but especially confidence in their ability to use these skills to benefit their own teaching.

Digital self-efficacy is also related to how teachers evaluate the benefits of technology for educational practices. For example, Scherer et al. (2015) emphasize that teachers who perceived themselves as competent users of digital devices also considered the use of technology in the classroom to be profitable for teaching and learning. This accentuates that personal perceptions have a significant impact on technology adoption. A recent meta-analysis (Scherer et al., 2019) related to teachers' adoption of digital technology, which utilized the popular technology acceptance model (TAM), confirms the importance of personal experiences and perceptions. Based on the synthesis of 114 empirical TAM studies, the meta-analysis shows that perceived usefulness and ease of use predict the intent to use technology for teaching through positive attitudes towards technology. In addition, the meta-analysis confirms that subjective norms play a key role in teachers' perceptions of the usefulness of technology, which affects the likelihood of their using it in teaching. Also, the digital self-efficacy and facilitating conditions, such as school or classroom resources, are linked to the perceived ease of use and usefulness and, therefore, act as a potential barrier or enabler for technology utilization in education (Scherer et al., 2019).

Kreijns et al. (2013) stressed that not only attitude and self-efficacy but also subjective norms influence teachers' technology usage in classrooms. Subjective norms are related to the pressure on teachers to use digital technology in their teaching (Kreijns et al., 2013). Technology use is thus facilitated not only by the teachers' personal perceptions but also by the external pressures they experience, for example, from the perceptions of other members of the work community. In addition to external pressure, work communities provide support: Hatlevik and Hatlevik (2018) show that collegial collaboration among teachers promotes the use of digital technologies in teaching practices. In relation to these themes, Helsper (2017) emphasized the role of digital referents as individuals assess the adequacy or inadequacy of their technology use in relation to social conditions and the key actors to which they feel they belong.

The present study focuses on the quantity and versatility of digital technology usage in teaching situations in pre-pandemic Finnish schools. The aim is to not only provide a perspective on the use of technology in pre-pandemic education in Finnish schools but also broaden research interest in the hierarchical structures that determine the teachers' education technology usage, revealing the levels at which this can be influenced. Therefore, the study analyses the importance of teachers' work communities and higher level implementation of education policy and of distinguishing the effects of different levels of nested hierarchies. From these starting points, the specific research questions in the present study are as follows:

1. How do Finnish teachers describe their use of digital technology in teaching in terms of the frequency and versatility of use?
2. To what extent is the quantity of digital technology usage in teaching explained by individual-level characteristics and to what extent by group-level effects?
3. Which teacher-related characteristics act as prominent predictors of variations in the quantity of technologies used in teaching?

4 | METHODOLOGY

4.1 | Participants

The data were originally collected in Finland during 2017–2019 for a project called "Comprehensive Schools in the Digital Age" funded by the Prime Minister's Office and the Ministry of Education and Culture. The data were collected from municipalities belonging to two representative samples of Finnish municipalities formed by the Finnish Education Evaluation Centre (FINEEC) based on the representativeness of the size and geographical location of the municipalities. The 2017 and 2018 sample consisted of 68 municipalities, and the 2019 sample consisted of 69 municipalities.

To analyse the between-schools effects and ensure that the data of some schools do not include only individual teachers who can be considered as pioneers in the field, we excluded respondents from schools with fewer than 10 teachers participating in the study. The data trimmed in this way consist of 2,355 respondents who came from 59 municipalities and 117 schools. Of these participants, 25% were male and 75% were female. Participants were 24–66 years old, with a mean age of 46 years (SD = 9.6). The final distribution of participants in the data by Finnish regional state administrative agencies (administrative districts) was as follows: Southern Finland 7%, Southwestern Finland 17%, Western and Inland Finland 30%, Eastern Finland 17%, Northern Finland 14%, and Lapland 15%.

In Finland, the first six grades of study take place mainly under the guidance of classroom teachers who are generalists and teach all subjects at the primary school level (ISCED level 1). Instead, subject teachers teach one or more subjects in grades 7–9 at the lower secondary school level (ISCED level 2) (see, Paronen & Lappi, 2018). Some basic education schools in Finland cover grades 1–6 and others cover grades 7–9. In addition, an increasing number of schools cover all nine class levels, forming a general comprehensive school. Of the participants 44% were teachers at primary schools and 56% at lower secondary schools. Of these, 929 were class teachers, 1174 were subject teachers, and the rest were counted as other teaching staff (i.e., special education teachers or student counsellors). As the limit was at least 10 teachers in the participating school, lower secondary level schools were overrepresented in the data in relation to their number, as in Finland many primary schools in small localities have fewer than 10 teachers.

Subject teachers were further categorized into three groups according to the subject they taught: STEM teachers (teachers who teach environmental studies, mathematics, physics, chemistry, biology, geography, or information technology); teachers of humanities and social sciences (teachers who teach mother tongue or foreign languages, religion, philosophy, history, social studies, or health education); and teachers of arts and skills (teachers who teach music, visual arts, home economics, crafts, physical exercise, or drama). The subject to be taught was not known to all subject teachers because it was not a mandatory question in the survey. To the extent that information is available, the data consist of 169 STEM teachers, 211 humanities or social sciences teachers, and 120 arts and skills teachers. The same teacher can teach subjects in more than one subject group, and thus they belong to more than one of the above groups.

4.2 | Measurement and variables

The data were collected using an instrument called the ICT Skills Test, which was developed in the Research Unit for the Sociology of Education (see, Kaarakainen, 2019). The digital test instrument includes a survey phase (see Data S1), during which the teachers' background information is collected (to identify the *school*, *municipality* and *administrative district*, *age*, *gender*, *teacher type*, i.e., whether the teacher is a class teacher or a subject teacher, and the subject taught by the participant, which is used to define the *subject group*), the extent to which (0%–100%) teachers perceive themselves as competent in digital skills related to their work (i.e., *self-efficacy*), and their experiences with the level of adequacy (0%–100%) of the *in-service training* (in digital skills) they have received so far.

The participants also were asked to evaluate how often they use different digital devices (desktops/laptops, tablets, and smartphones) as well as digital materials and applications (online learning materials, video services, educational games, the Internet for browsing information, email, office suite applications, blogs, digital tools for student evaluation, social networking services, digital learning environments, and smartphone applications) for teaching at their work. The following scale was used: 0 = "never", 1 = "sometimes", 2 = "weekly", 3 = "daily", 4 = "several hours per day". The variable *technology usage in teaching* describes the quantity of usage formed from the three questions about the use of digital devices in such a way that the value of this variable was considered to be the maximum use of any type of device for each participant. In this way, for example, the result of "several hours per day" was reached by using at least one type of device for several hours a day. In addition, to examine the quality of use, the variable *versatility of usage* was formed by summarizing the digital services and tools used by each teacher at least weekly (considered as regular use) (α = 0.8, N= 11). The test measuring digital skills (Table S1) was undertaken after the questionnaires. The ICT skills test for teachers consists of 15 items, each of which produces a maximum of 2 points. Only the total score of *digital skills* was utilized in this study (α = 0.9, N = 15). The data with the variables defined in this section are stored anonymized in their raw form in the general open access data repository Zenodo for long-term storage and further use (Kaarakainen & Saikkonen, 2020).

4.3 | Analysis

In an effort to answer the research questions posed in this study, the data were analysed using mainly descriptive methods (supplemented by one-way analysis of variance (ANOVA) and correlation analysis) and multilevel modelling. As the variables include categorical and ordinal-scaled variables, Spearman's rank correlation coefficient was used as the correlation test (see, Caruso & Cliff, 1997).

Education-related topics are characterized by relationships between individuals and the structures of society. Not only students but also teachers as individuals interact with the social and structural conditions to which they belong in their work. In multilevel modelling, individuals and social conditions are understood as a hierarchical system that allows to be monitored and variables to be defined at each level. In order to detect group-level characteristics in individual-level manifestations, multilevel analysis is required, as applied in this study (see, e.g., Asparouhov & Muthen, 2006; Hox, 2010). It is well known, for example from a student performance study, that structural hierarchies matter, and as a result of these grouping effects, individuals are no longer independent on subsequent analyses (e.g., Ma et al., 2008). Therefore, the impact of grouping effects on schools, municipalities, and wider administrative districts on the teachers' digital technology usage should be controlled in research to avoid misleading estimates and interpretations.

To compare differently scaled variables, it is generally recommended in the case of multilevel modelling to centre the variables (e.g., Enders & Tofighi, 2007). In nested or grouped data, as in the case of the data from this study, there are two possibilities for centring. In the case of grand-mean centring, the sample mean is subtracted from each individual's predictor score (i.e., $x_{ij}–\bar{x}_j$). In turn, in the case of group-mean centring, the predictor mean for the group into which the individuals are nested is subtracted from the predictor scores for each individual within that group (i.e., $x_{ij}–\bar{x}_j$) (Peugh, 2010).

As Peugh (2010) notes, there is no universally valid guideline for choosing the right method, but choosing a suitable centring method always depends on the research question. In this study, grand-mean centring was applied, as it provides a more comprehensible interpretation of the estimates obtained, and there were no differences in the main effects of the results when testing these two centralization methods. In any case, centring should be applied to both continuous and categorical variables in the Level 1 model (Enders & Tofighi, 2007), and therefore all variables used in the multilevel analyses were centralized. In addition, outliers were removed from each variable before the multilevel analyses. Missing values were also analysed, and as the missingness was not found to be systematic, they were left untreated.

More specifically, a linear mixed-effect model was used in the present study. The method is similar to the general linear model but includes both fixed and random effects in the same model; therefore, the outcome variable is affected by fixed and random effects (as well as an error term). The model is usually presented as an equation:

$$y_{ij} = \beta_1 x_{1ij} + \beta_2 x_{2ij} \ldots \beta_n x_{nij} + b_{i1} z_{1ij} + b_{i2} z_{2ij}, \ldots, b_{in} z_{nij} + \varepsilon_{ij},$$

where y_{ij} is the value of the outcome variable for a particular *ij* case; β_1 through β_n are the fixed-effect coefficients (similar to regression coefficients); x_{1ij} through x_{nij} are the fixed-effect predictor variables for observation *j* in group *i*; b_{i1} through b_{in} are the random-effect coefficients; z_{1ij} through z_{nij} are the random-effect predictor variables; and ε_{ij} is the error for case *j* in group *i* (see, e.g., Pinheiro & Bates, 2000).

With the data containing only individual-level features, the modelling in this study is limited to level-1 predictors only. Despite the lack of predictors at further levels, the data contain a total of four nested levels (administrative area, municipality, school, and teacher), and its relevance to the issue under consideration is one of the modelling objectives. Analyses were performed with IBM SPSS Statistics software (version 25) utilizing restricted maximum likelihood (REML) for estimation. The Akaike information criterion (AIC) and Bayesian information criterion (BIC) were used to evaluate the model's goodness of fit.

5 | RESULTS

On average, digital devices are used in teaching by Finnish teachers on a weekly or daily basis (*M* = 2.26, SD = 0.91). This is shown in Figure 1, which illustrates teachers' responses to the question about how often they use digital devices in teaching. The "any device" bar shows the total usage of different types of devices based on the most used device type. Therefore, individual device-type bars cannot be included in the total usage (i.e., any device bar). The most common types of devices used regularly are desktop and laptop computers, used by a third of teachers on a daily basis and another third at least once a week. Mobile devices such as tablet computers and smartphones are most typically used occasionally. When looking at the total amount of device usage, only a few individual teachers do not use technology in their teaching at all and roughly a fifth only occasionally.

The participating teachers reported using education technology mostly for seeking information (see Table 1): about 40% of teachers say they use technology for searching information on a daily basis and another 40% on a weekly basis in their teaching. The second most common use of technology in teaching is online learning materials. Still, their use is already much rarer, with only about 10% of teachers using them daily and less than 40% using them weekly. After these two, the most commonly used digital services or tools in teaching are email, digital learning platforms, office suite software, and video services such as YouTube. The density of use for all of these in teaching situations remains, on average, occasional or weekly among teachers. The least used digital services or tools by teachers are the various

TABLE 1 Frequency of the use of various digital services and tools in Finnish teachers' responses

Digital service or tool	*M*	*SD*
Internet for information searching	2.23	0.82
Online learning materials	1.92	1.06
Email	1.72	1.19
Digital learning environments	1.65	1.04
Office suite software	1.56	0.96
Video services	1.53	0.77
Learning games	1.30	0.80
Mobile applications	0.93	0.84
Digital evaluation tools	0.71	0.78
Blogs	0.58	0.65
Social networking services	0.48	0.67

Note: Scale: 0 = "never", 1 = "sometimes", 2 = "weekly", 3 = "daily", 4 = "several hours per day".
Abbreviations: *M*, mean; SD = standard deviation.

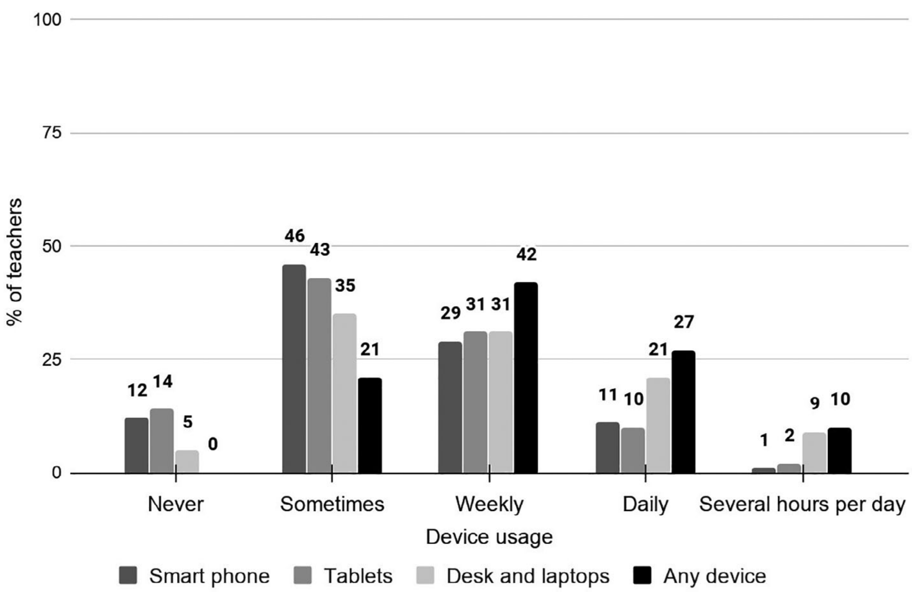

FIGURE 1 Frequency of the use of different types of devices in teaching (values are rounded to the nearest whole number)

social media networking services followed by blogs. According to the responses, Finnish teachers do not assess their students with digital tools. Likewise, the use of mobile applications or educational games is also reasonably low according to the responses of Finnish teachers. On average, participants report using all of these only occasionally at most, if at all.

In terms of the versatility of usage, participating teachers regularly use an average of 3.7 (SD 2.28) applications of digital technology in their teaching. About one-fifth of the teachers used at least six digital technology applications on a regular basis in teaching situations, while the proportion of those who report not using any or only one of the applications is also one fifth. (Figure 2.)

Information on the subject taught by the subject teacher was missing from a large number of the respondents because of its non-mandatory nature, which is why the information was not utilized in further multilevel analyses. To the extent that data on the subjects taught were available, a one-way analysis of variance revealed that there is a significant effect of quantity of usage at the $p < 0.001$ level for the four different groups of teachers [$F(3, 1404) = 6.157$, $p < 0.001$]. Post hoc comparisons using the Tukey HSD test indicate that the average quantity of usage for the humanities or social sciences teachers ($M = 2.47$, SD = 1.00) is significantly higher than the class teachers ($M = 2.22$, SD = 0.82) and the arts and skills teachers ($M = 2.08$, SD = 0.89). However, the average quantity of usage for the STEM teachers ($M = 2.28$, SD = 0.97) does not significantly differ from that of the humanities and social science teachers. No other differences were found between the groups.

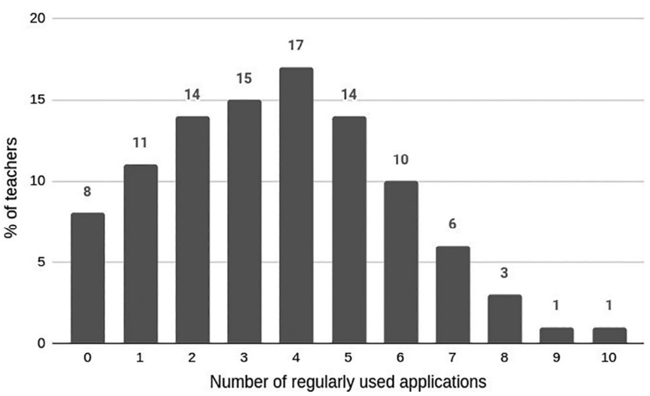

FIGURE 2 Versatility of the applications of digital technology used by teachers on a regular basis

Also the effect of versatility of usage at the $p < 0.001$ level for subject groups is revealed to be significant [$F(3, 1405) = 15.430$, $p < 0.001$]. Post hoc comparisons indicate that the class teachers ($M = 4.05$, SD = 2.19) are significantly more versatile users of digital technology in teaching than both the STEM teachers ($M = 3.23$, SD = 2.30) and the arts and skills teachers ($M = 3.17$, SD = 2.19). Similarly, the humanities and social science teachers ($M = 4.00$, SD = 2.18) are significantly more versatile users than the STEM teachers and arts and skills teachers.

The linear bivariate correlations between variables (from non-centralized values) are shown in Table 2, revealing that the correlations between the quantity of technology usage and digital skills, digital self-efficacy, and in-service training are minor, albeit positive. The technology usage and other examined variables have no observable linear bivariate relationship. Instead, the mutual correlation between digital skills and both digital self-efficacy ($\rho = 0.45$) and related in-service training ($\rho = 0.32$) is clearly observable. Also, the correlations of age with digital skills ($\rho = -0.41$) and digital self-efficacy ($\rho = -0.29$) are to be noted: both are weakened by the ageing of teachers.

The first step in multilevel modelling is to ensure that the approach is appropriate in the first place. Therefore, an unconditional model (i.e., the "intercept-only" model) was performed first, and only the dependent variable and grouping variables (administrative district, municipality, and school) were added to the model. The results of the multilevel analysis are shown in Table 3, which shows that, except the administrative district proves to be redundant, 5% of the variance in the quantity of digital technology usage in teaching occurred at the municipal level (intraclass correlation coefficient, ICC = 0.050) and the same 4% at the school level (ICC = 0.043), denoting the relevance of the multilevel analysis. Even at this stage, however, it is clear that most of the teachers' technology usage is explained at the individual level, that is, by variation among teachers within schools.

When teacher-level variables are added in the level-1 model, attention is first drawn to the covariance parameters: now, both the municipality and the administrative district are proving to be redundant levels in the model. In contrast, the importance of the school

TABLE 2 Descriptive statistics and correlations between variables

Variable	M (SD)	1	2	3	4	5	6	7
Gender (0 = female)	0.25 (0.43)	1						
Age	46.15 (9.57)	0.05**	1					
Teacher type (0 = class teacher)	0.56 (0.50)	0.11***	−0.04	1				
Digital skills	16.61 (4.93)	0.15***	−0.41***	0.09***	1			
Digital self-efficacy	0.60 (0.37)	0.16***	−0.29***	0.06*	0.45***	1		
In-service training	0.36 (0.38)	0.09**	−0.20***	0.05	0.32***	0.67***	1	
Technology usage in teaching	2.26 (0.91)	0.01	−0.01	−0.01	0.14***	0.12***	0.10**	1

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

TABLE 3 Multilevel unconditional model and model with teacher-level variables for teachers' technology usage in teaching

	Unconditionalmodel		95% CI		Model with teacher-level variables		95% CI	
Parameter	Estimate	*SE*	Lower bound	Upper bound	Estimate	*SE*	Lower bound	Upper bound
Fixed								
Intercept	1.014***	(0.018)	0.977	1.051	0.481	(0.109)	0.266	0.695
Gender (0 = female)					0.040	(0.028)	−0.015	0.096
Teacher type (0 = classroom teacher)					−0.011	(0.026)	−0.062	0.041
Age					0.227**	(0.067)	0.096	0.357
Digital skills					0.213***	(0.057)	0.102	0.324
Digital self-efficacy					0.060*	(0.028)	0.004	0.116
In-service training					−0.001	(0.015)	−0.030	0.029
Random								
Residual	0.146	(0.004)			0.150	(0.007)		
Administrative district	-	-			-	-		
Municipality	0.008	(0.005)			-	-		
School	0.007	(0.003)			0.011	(0.004)		
Goodness of fit								
AIC	2270.863				1125.442			
BIC	2293.903				1145.403			
Modelled variance								
Administrative district level	0%				0%			
Municipality level	5%				0%			
School level	4%				7%			
Individual (teacher) level	91%				93%			

Note: Predictors were grand-mean-centred.
Abbreviations: AIC, Akaike information criterion; BIC, Bayesian information criterion; CI, confidence interval; SE, standard error.
***$p < 0.001$, *$p < 0.05$.

level slightly increases compared to the unconditional model. The same is true for the individual level as well. Thereby, most of the variation in the quantity of teachers' education technology usage, 93%, is explained by differences among teachers within schools, and only 7% is explained by differences between schools (ICC = 0.068).

The examination of individual-level predictors reveals that digital skills, age, and digital self-efficacy significantly increase the quantity of teachers' education technology usage. The results show that when controlling for other variables, a 1-unit increase in age is associated with a 25% (exp(.227) ≈ 1.254) increase in teachers' technology usage in teaching; thus, a 1-unit increase in digital skills is associated with a 24% (exp(.213) ≈ 1.237) increase in usage, and a corresponding increase in digital self-efficacy is associated with a 6% (exp(.060) ≈ 1.062) increase in technology usage. In contrast, the effects of gender, whether the teacher is a class teacher or a subject teacher, and in-service training in digital skills remain insignificant. The interactions tested did not improve the model, and as the data do not include appropriate variables for higher level models, and even school-level aggregate variables did not improve the model, the level-1 model is reported with only the main effects.

6 | DISCUSSION

The first research question of the present study is related to the quantity and versatility of digital technology usage in teaching among Finnish teachers. Utilizing the data from a few years before the outbreak of the global coronavirus pandemic, it was observed that Finnish teachers used digital devices in their teaching at least weekly on average, many on a daily basis. However, only 1 in 10 teachers reported using digital technology in their teaching for several hours a day, whereas 2 in 10 said they use digital devices in teaching only occasionally. In terms of versatility, teachers typically reported using three or four digital tools or services regularly (at least weekly) in their teaching, mainly to present lesson content, browse for information, and to communicate with students.

The results of the present study suggest that the subject taught by the teacher has an impact on the integration of technology in teaching. For example, the fewer the practical assignments required by the subject content, the more suitable it seems for digitized teaching. These differences are likely related to the nature of the different school subjects and the prevailing traditions in their teaching practices as well as in the availability and cost of curriculum-based educational technology products for these subjects at distinct levels of education. It is clear that the cost of specialized hardware, software, and learning products that provide interaction and simulation or experiences of immersion is relatively high, which has become a barrier, for example, to the utilization of learning games in teaching (e.g., Tsekleves et al., 2016). In addition to the key importance of the ease of use and usefulness of technology which has become familiar through technology acceptance studies (see, e.g., Scherer et al., 2019), the economic reality of schools, that is, one form of facilitating conditions (cf., Scherer et al., 2019), directly impacts the integration of technology into teaching in schools: subjects with more affordable digital learning products are likely to be more easily digitalized than others. However, more research on the topic is required.

Differences in the progress of digitalization in teaching have presumably had an impact on the experiences of the distance-learning period during the coronavirus pandemic. According to the World Bank summary (WB, 2020), during school closures in spring 2020 in Finland, students were provided with instruction using alternative digital methods, including distance learning, digital learning environments and solutions, and, if necessary, through guidance on independent learning. Digital tools for teaching, particularly remote conferencing or remote meeting tools, were commonly used during the distance-learning period, allowing students to complete projects and assignments independently and participate in online teaching. As stated in the summary (WB, 2020), it is an established practice in Finland to organize communication between home and school through online platforms. These online tools are used to send feedback and communicate learning assignments, test scores, and grades between home and school, and they are typically integrated into other administrative information systems within the school. Such practices have undoubtedly been useful in the transition of Finnish schools to distance learning. For teachers, however, the distance-learning period has presumably posed unevenly distributed challenges, as they have been accented in disciplines that used the least amount of technology before the pandemic, and ready-made applications were not available. In addition, it is expected that challenges have accumulated for teachers whose technology use before the pandemic was limited owing to lack of experience, skills, or motivation.

The second question in this study relates to the extent to which the digital technology usage in teaching is explained by teachers' individual characteristics and to what extent by group effects. Multilevel modelling reveals that most (93%) of the differences in the quantity of teachers' technology usage are at the individual level among teachers within schools, and the rest (7%) are situated between schools. The effect of municipalities and wider administrative areas proves to be redundant in explaining teachers' technology usage. This is consistent with a previous study by Salokangas et al. (2020), who showed that a large part of school-level decision making concerning educational, social, and developmental issues in Finnish schools is usually in the hands of teachers (either collegially or individually). Despite the unity of school funding and the shared national core curriculum, the autonomy of the teaching profession is characteristic of Finnish education, extending from planning, teaching, and assessment to the development of one's own professional skills (Salokangas et al., 2020). In general, this also covers decisions about the environments (digital and non-digital) that teachers want to use in their own teaching within school resources.

Although the individual level can be expected to be particularly relevant in countries with high teacher autonomy, the importance of the individual level has also been recognized more widely internationally; for example, the OECD (2015) states that, in general, technology use in teaching depends mainly on teachers themselves and not so much on school-level policies. However, as Scherer et al. (2019) emphasize, facilitating conditions such as school resources play a role in preventing or promoting the integration of technology into teaching. It is therefore to be assumed that, despite the independence of the teaching profession in Finland, school resourcing is influential in the use of technology in teaching. Finnish teachers are guided by municipal regulations and state legislation; in particular, issues related to digitalization often include municipal involvement (e.g., Salokangas et al., 2020). For this reason, the municipality's redundancy for technology usage in teaching observed in this study is somewhat surprising. As municipalities in Finland act as education providers and are responsible not only for the development of digital infrastructures but also the related general regulations and resource allocation, it would have been assumed that they had some grouping effect on the use of technology in schools.

The dominant role of the individual level for teachers' education technology usage has a major impact on the implementation of education policies aimed at digitalizing education and learning. An exemplar of this problematic situation can be found in the observations of the digitalization of Finnish education. According to Saari and Säntti (2017), Finland's strategy in digitalizing education has been to convince local administrators, principals, and individual teachers about the need for a critical "digital leap". Such simultaneous multilevel persuasion is the only tactic available, as Finland has had a relatively decentralized structure in the implementation of national core curricula since the 1990s. In their study, Saari and Säntti (2017) found that although administration, organization, and curricula in Finnish schools changed significantly with digitalization goals in the 2010s, these structural changes were not able to change the core of pedagogical activity: teachers seem to have largely continued teaching, as they have for ages. Therefore, for its part, the results of the present study suggest that education providers, that is, the municipal and school levels, have largely failed to achieve leadership in coordinating the digitalization of learning environments and teaching practices in schools. This allows individual teachers to decide whether to promote digitalization goals, increasing the risk of uneven progress in the digitalization of education.

As individual-level decision-making power in relation to digitalization increases, not only in Finland, but presumably more broadly, the risk that digital tools introduced to teaching by individual teachers do not meet authority requirements, for example, in terms of data protection (see, e.g., Har, 2016). The associated risk, accelerated by individual teacher decision making, is the growing leakage of decision-making power from public sector education providers to private-sector technology vendors (e.g., Har, 2016; Hogan et al., 2018). This risk is already said to have been exacerbated during the pandemic, as schools and teachers around the world have had to adopt digital solutions from technology providers in a short time frame, creating a so-called seller's market (Teräs et al., 2020; Williamson, 2020). As Selwyn et al. (2020) point out, technology providers around the world are promoting the privatization of digital infrastructures in education, giving large educational technology players a foothold as a leading educational force. As Verger (2016) pointed out, for reasons of efficiency, the shift of power from public to private actors may seem convenient, but it inevitably means weakening democratic control of public education. It has also been said (see, Williamson et al., 2019) that education technology and policy have had a strange relationship with the technology industry from the very beginning, characterized by a lack of governmental interest.

For the third research question, the present study examined which teacher-level characteristics predict the variation in how much technology is used in teaching, with a focus on individual-level predictors. A close examination of the teachers reveals that when other variables are controlled, digital skills, age, and digital self-efficacy have a significantly greater effect on the quantity of teachers' digital technology usage, particularly on the role of teachers' digital skills and self-efficacy as promoters of the digital technology usage in their teaching, confirming the results of previous research (e.g., Az-eddine & Hicham, 2017; Hatlevik, 2017; Hatlevik & Hatlevik, 2018; Kreijns et al., 2013; Nikolopoulou & Gialamas, 2016; Scherer et al., 2015). At first sight, the surprising effect of age on the quantity of technology usage is due to the fact that, with the exception of teachers under the age of 30 (clearly the highest usage) and teachers over the age of 60 (clearly the lowest usage), increasing age does actually increase the teachers' technology usage in teaching. In a previous study (Drossel et al., 2017), teachers' experiences with education technology have been found to increase their use of technology in teaching. Similarly, the pattern of age observed in the present study suggests that the accumulating experience of professionally mature teachers, especially in terms of using education technology in pedagogical activities, is likely to increase the integration of digital technologies into teaching situations.

Although the effect of in-service training remained insignificant in the multilevel analysis, based on a bivariate correlation analysis, it is engaged with digital self-efficacy. In-service training in digital skills is thus likely to have an indirect effect on teachers' technology usage, mediated through self-efficacy. Based on the results of this study, in-service training should aim in particular to increase digital self-efficacy while improving technology perceptions and ease of use in teaching (e.g., Scherer et al., 2019) in order to encourage teachers to integrate technology into their pedagogical practices.

7 | LIMITATIONS OF THE STUDY

The empirical part of this study re-used data collected in previous projects. Reusing research data inevitably forces us to approach research from the perspective of what the data allows to be questioned. Empirical data, utilized in this way, is often incomplete, at least to some extent, but reusing it still has value, although it requires the identification of its limitations. In this case, the main limitations were related to the representativeness of the data and the lack of level-2 (or higher) predictors. The lack of representativeness is mainly related to the fact that the sampling is based on municipalities, and participation was voluntary for both schools and teachers, with many from both levels being reluctant to participate. In practice, this caused many schools to drop from the trimmed data used in this study, as the limit for teachers in schools (at least 10) was not met in all schools of the original data.

The original survey that produced the data did not include questions about, for example, collegial support and subjective norms related to digitalization in the work community, digitalization-related resources and leadership in schools, or general policies and regulations issued by the teachers' work community (school) or education provider (municipality). Therefore, many potentially interesting high-level predictors are missing from the data. This limited the present study to focus solely on individual-level predictors in addition to determining whether grouping effects are observable in the data. This is a clear shortcoming of this study, and school-level information on digitalization-related resources, collegial support, and leadership practices will likely provide important factors to explore for future research.

It should also be noted that the individual level is likely to be emphasized in Finnish data precisely because of the decentralized education administration. Therefore, in education systems with different administrative practices, the grouping effects in the use of digital technology in teaching are likely to manifest differently than the effects described in this study. For example, centralized education administration versus decentralized decision making is presumably producing differences in the emergence of education systems' grouping effects.

8 | CONCLUSION

Digital technology in teaching is influenced by a variety of structural levels and factors. Based on the results of this study, the variation in teachers' technology usage in teaching occurs mainly at the individual level, and only a small proportion of the differences is explained by differences between schools. Thus, the changes brought by goals to digitalization of education have had a particular impact on the working methods of some teachers, not necessarily on the daily activities of teachers' work communities, that is, schools as a whole. Selwyn et al. (2017) have stated that the apparent technological "effects" on teachers' work should be broadly understood. They emphasize that there has been no major change in the work process of teaching per se. Therefore, digital technology in education is mainly used in ways that retain established informational, communicative, and management practices. Research needs to account for the wider context in which teachers operate, such as the social, political, and economic infrastructures into which these new technology-based forms of work are embedded.

Previous research have emphasized the need for a multidimensional approach in research in the field that transcends the individual level, that is, the personal competences and beliefs of teachers (e.g., Scherer et al., 2019; Straub, 2009). Helsper (2017) has emphasized the need to take social contextuality into account, as current research has increased knowledge of the sociodemographic factors associated with digital exclusion, access, skills, and engagement, but explanations of why or how individuals' positions evolve or how they could change are largely lacking. Based on this study, it also seems to be desirable to apply a multilevel approach to future research in order to examine whether individual characteristics are independent enough to assume that they can have practical relevance as predictors of teaching practices and what kinds of grouping effects emerge in different contexts of education policy implementation.

Future research should especially focus on the unprecedented educational disruption caused by the coronavirus pandemic. Based on this study, the focus should be, for example, in examining the extent to which digital technologies introduced during the distance-learning period in the spring of 2020 will remain part of normal teaching practices after the pandemic. It remains to be seen whether the common situation of coercion has long-term effects, or we will return to the mode of individual-level drifting digitalization after the crisis. There are also other unknown issues regarding inequality, the effects on learning outcomes, and changes in the grouping effects of the digitalization of education. The latter refers, for example, to whether the role of schools or municipalities as promoters of digitalization was strengthened in exceptional circumstances or whether technology vendors gained an even greater foothold in decision making regarding the digitalization of schools.

Education in the post-coronavirus era will be a momentous research field, especially globally. D'Orville (2020) points out that even before the pandemic, the world was facing a "learning crisis", pointing to a lack of equality, a high drop-out rate, and insufficient learning. However, global education could benefit from better and more digital education solutions developed and implemented during the corona crisis. The post-pandemic era is thought to provide an opportunity for what we now call distance learning, creating a foundation for a more continuous learning process that ensures that children around the world learn basic skills (Saavedra, 2020). Therefore, all over the world, the focus should now be on rebuilding a better education—not just restoring the pre-pandemic situation (see, d'Orville, 2020). These emerging prospects after the first shock of the crisis make the use of digital technology in teaching an even more interesting factor not only in improving education but particularly in research in the field.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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DATA AVAILABILITY STATEMENT

The data with the variables defined in this article are stored anonymized in their raw form in the general open access data repository, Zenodo, for long-term storage and further use (Kaarakainen & Saikkonen, 2020). http://doi.org/10.5281/zenodo.4000217.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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