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Quality over frequency in using digital technology: Measuring the experienced functional use

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ABSTRACT

Digital technology has a lot of potential in terms of teaching and learning. However, experimental and especially survey studies have provided mixed evidence on the impact of digital technology on educational outcomes. The correlation between students’ reported use of digital technology and achievement has continually appeared to be of no significance or even negative significance. Instead of measuring the perceived frequency of using digital technology, we developed an instrument to measure the experienced quality of such use. Theoretically, we build on Martin Heidegger’s conceptualisation of present-at-hand as a non-functional use of digital technology and ready-to-hand as a functional use of digital technology. Altogether, 203 secondary school students (aged 13–16 years) responded to the questionnaire. The structural equation model revealed that experience of non-functional use of digital technology had a statistically significant impact on perceived frequency of using digital technology at school, while experience of functional use of digital technology had a statistically significant impact on academic achievement. Like in previous research, the reported frequency of digital technology use did not have a statistically significant impact on academic achievement. We highlight that Heidegger’s conceptualisation of present-at-hand and ready-to-hand helps us to understand the mixed results of international surveys. We conclude that, to better understand the role of digital technology in learning, in surveys as well as in the classroom, the focus should be on the experienced quality of learning—functional use—instead of the perceived frequency of the use of digital technology.

1. Introduction

Evidence of the impact of using digital technology on academic achievement is mixed. Particularly in large-scale international studies—such as the Programme for International Student Assessment (PISA) or Trends in International Mathematics and Science Study (TIMSS)—the correlation between students’ reported use of digital technology and achievement has continually appeared to be of no significance or even negative significance (e.g. Biagi & Loi, 2013; Bielefeldt, 2005; Hu et al., 2018; Skryabin et al., 2015; Spiezia, 2010). In contrast, the meta-analyses of experimental and small-scale studies have shown positive effects of technological applications on student performance in various subject areas such as literacy, mathematics and science (Chauhan, 2017; Cheung & Slavin, 2012, 2013; Sung et al., 2016). It appears that the potential benefits of digital technology use might not be visible in surveys, in which the measurement is based on the reported frequency of technology use. Yet, the lack of positive impact based on large-scale surveys often evokes critical debate on whether schools should invest in costly educational technologies and the practical problem of the extent to

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which their application should be encouraged (Cuban, 2001; Goolsbee & Guryan, 2006; Lim et al., 2013; Luschei, 2014).

In this study, we address the intellectual problem of the mixed results by critically elaborating on measuring the perceived frequency of digital technology use. We hypothesise that non-existent or negative correlations between reported digital technology use and academic achievement could be explained by experiences of using digital technology in non-functional ways. As an alternative approach to measuring the frequency of use, we develop and test ways to measure the experienced functional use of digital technology.

1.1. Towards measuring the quality of digital technology use

We use the term digital technology as an overarching label, including devices and activities such as using e-mail, browsing the internet, playing simulations, using school computers or mobile device for group work, or applying subject-specific applications like data logging. While the use of digital tools and software in learning has increased significantly over the last decades, determining its effectiveness in learning has proved to be complicated. As suggested by the above-mentioned discrepancy between international surveys and smaller-scale experimental studies, there are many variables that need to be taken into account, and the results can be complex. For example, the intensity of the use of digital technology has been reported to affect student achievement, with a moderate frequency of digital technology use correlating with higher levels of achievement and high and low frequencies of digital technology use having a detrimental effect (Meggioraro, 2018; Meng et al., 2019; Organisation for Economic Co-operation and Development [OECD], 2015; Shewbridge et al., 2005). Gubbels et al. (2020) found that moderate use of digital technology was related to high performance in reading, while excessive use of digital technology was associated with lower reading performance. Based on their literature review, Fernández-Gutiérrez et al. (2020) concluded that both experimental studies and international surveys provide mixed evidence on the impact of digital technology on educational achievements. The authors themselves found a difference between subjects. According to their analysis of PISA data, an increase in the use of digital technology in school was associated with higher science performance, but no such increase was found in mathematics or reading.

The complex results have led to conclusions that the potential of educational technologies has not been sufficiently harnessed in schools, and the weak results of large-scale studies may have been caused by ineffective pedagogy when teaching and learning with technology (OECD, 2015; Tamim et al., 2011). If this is the case, the question arises of how the quality of the experienced use of digital technologies could be measured.

Overall, it appears to be more difficult to demonstrate the impact on educational achievement in correlational studies than in experimental studies (Seidel & Shavelson, 2007). For example, a computer-assisted interactive reading model with specific characteristics used in certain ways in blended and distance-learning contexts has proven to be efficient (Bahari et al., 2021), but in a survey on digital technology use such specific activities are blended with everything else. This is so because large-scale assessments tend to focus on the reported frequencies—usually time duration—of using (certain) digital technology instead of the quality of teaching and learning with the technology (Lei, 2010). Furthermore, surveys are commonly based on the assumption that students can estimate the frequency of digital technology use. The time is usually measured as the reported frequency of use, for example, from “No time”, “1–30 minutes per day” to more than 6 hours per day” (OECD, 2017). However, such a scale is prone to fail when measuring infrequent but intensive phases of technology use; moreover, it does not account for the quality of time spent with the technology. It has been suggested that more sophisticated factors with respect to student digital technology than those which are presently used in large scale studies should be explored (Hu et al., 2018).

Large-scale studies have incorporated mediating and moderating variables, but not even this has provided an empirical explanation for the lack of positive effects of digital technology use (Ainley et al., 2008). Approaches to solving this problem have included calculating separate effect sizes for different types of educational technologies (Hattie, 2008; Tamim et al., 2011), for learning in different subjects (Cheung & Slavin, 2012, 2013) or for different intervention durations (Chauhan, 2017). A closer examination of these studies shows that there are usually high standard deviations for these effect sizes, indicating that there is considerable variation even within each type of educational technology or within different subjects or durations of use. This suggests an assumption that the quality of digital technology use depends not only on the type of technology and the purpose of use, but also on how the technology is implemented (see Petko et al., 2017).

Some alternative approaches to investigate the quality of digital technology use through surveys have been proposed. Petko et al. (2017) showed that positive attitudes towards digital technology are associated with higher academic achievement in most PISA countries. The authors suggested that positive attitudes stem from positive experiences of digital technology, which result from high-quality technology use in schools. Bergdahl et al. (2020) developed a measurement of engaging and disengaging in technology-enhanced learning and showed that high-performance students reported higher engagement. The authors showed how emotional, behavioural, cognitive and social dimensions of engagement differ between low- and high-performance students, and suggest that high-performing students have developed strategies to use digital technologies in supportive ways, for example by resisting urges and avoiding distractions. The above-mentioned studies approach the quality of technology use indirectly though concepts of attitude and engagement, both of which are considered (and showed) to be associated with academic achievement. Whereas the findings of Bergdahl et al. (2020) suggest that some direct technology-related experiences such as diversions and distractions affect concentration on work, their measurements and also those of Petko et al. (2017) prioritise the affective relationship towards the use of digital technology or its perceived cognitive outcomes. However, there is evidence that not even attitudes concerning technology and its perceived usefulness are commensurate with the actual application behaviour (Lee et al., 2019).

Based on the above, it seems that more direct ways to capture the experienced quality of digital technology use are needed. In particular, attempts to measure the (self-reported) quality of technology use lack a focus on how the technological devices themselves and how they are experienced when used. Yet, the quality of use is determined primarily in the process of using the devices, within
which the affective side is also integrated (Roth & Jornet, 2019).

1.2. Research question

In this study, we question the assumption of relying on the self-reported frequency of digital technology use by elaborating on what is meant by asking about and reporting the experiences of digital technology use itself. We hypothesise and test an alternative approach to asking about the use of digital technology in learning. Instead of reporting merely the (perceived) frequencies of use or the related affective factors, our contribution to the field is to explore how the experienced high or low quality of the instances of technology use during and for learning can be operationalised in a more direct way, and what its relation to academic achievements may be.

Theoretically, we build our approach to measure the experienced quality of digital technology use on philosopher Martin Heidegger’s (1962) general analysis of the functional use of tools and appliances (ready-to-hand). We suggest that the reported non-significant or negative correlations between technology use and achievement can result from the experienced functionality and serviceability that the technologies may or may not grant when used for learning purposes. We hypothesise that the non-functional use of educational technology (present-at-hand) can explain the poor correlation between reported technology use and academic achievement. To investigate this, we developed a questionnaire based on functional and non-functional technology use of digital technology in learning and analysed the relations between the experienced quality of digital technology use, perceived time of use and reported academic achievement from the data of middle school students.

The research question is as follows: what is the impact of experienced functional use and non-functional use on the perceived frequency of digital technology use in school and the reported academic achievement?

2. Theoretical background

To operationalise and analyse the functionality of the use of digital technology, we draw from Heidegger’s distinction between two modes of relating with devices. In his analysis of involvement with the practical context of the world, Heidegger (1962) contrasted two categories of dealing with the world and its resources (e.g. tools, appliances, implements)—readiness-to-hand and presence-at-hand.

The first and primary category for perceiving and experiencing a resource is to encounter it as ready-to-hand. Typically, in our everyday activities, the resources that we use do not require any conscious awareness or attention as items themselves. Heidegger raised the example of a carpenter using a hammer. In the activity, the carpenter does not think of the hammer as an object with certain properties, such as its shape, weight or colour. Instead, what constitutes a hammer is bound to the ways in which it is used, that is, hammering. Thus, a hammer is primarily a piece of equipment, and as Heidegger (1962) argued, equipment ‘is essentially “something-in-order-to…”’. A totality of equipment is constituted by various ways of the “in-order-to”, such as serviceability, conduciveness, usability, manipulability’ (p. 97). Thus, the equipment is used primarily in order to achieve something toward some goal and for the sake of that whole act of using the technology. To capture what a hammer is, one must describe something used to hit nails with, in order to attach pieces of wood together, in order to construct something, in order to make sense of one’s activity as a carpenter. Heidegger continued to describe how equipment that is ready-to-hand must ‘withdraw in order to be ready-to-hand quite authentically’ (p. 99). Dreyfus (1991) referred to this tendency to withdraw from the consciousness as the equipment becoming transparent. A hammer is transparent to a carpenter as long as it serves its purpose of hammering. Another commonly used example is a blind person with her cane: the cane ceases to be an object of consciousness that is perceived for itself, becoming ‘transparent’ in use (Ihde, 1976).

Yet, if the hammer or the cane ceases to fulfil its purpose, another category and mode of its being becomes relevant. Accordingly, it is possible to consider digital technologies. The technologies make sense for the participants of the activity only in relation to the whole event that is in use (Ihde, 1976). A totality of equipment is constituted by various ways of the “in-order-to”, such as serviceability, conduciveness, usability, manipulability’ (p. 97). Thus, the equipment is used primarily in order to achieve something toward some goal and for the sake of that whole act of using the technology. To capture what a hammer is, one must describe something used to hit nails with, in order to attach pieces of wood together, in order to construct something, in order to make sense of one’s activity as a carpenter.

When a carpenter needs to hit nails, but the hammer is missing or broken, attention is drawn to the item with certain properties. When attending to the missing hammer or trying to solve the problem of its malfunction, the carpenter considers the hammer as a theoretical object. Instead of being a piece of equipment ready-to-hand in order to do work, the hammer now appears as a mere thing, something present-at-hand. In Heidegger’s (1962) terms, the environment that is present-at-hand is brought ‘closer in circumspective deliberation’ (p. 410). Instead of the hammer being a transparent part of the activity of hammering, realisations like ‘the hammer is heavy’ or ‘the hammer is broken’ become conscious and relevant. Moreover, aspects that were imperceptible in the everyday activity, such as the causal connection between hammering and nails hitting the wood, become explicit or problematic.

Heidegger’s work problematises the existence of an inherently structured world with clearly identified resources, tools and phenomena. Harman (2011) argues that every object is a tool-being. Thus, the theoretical categories of dealing with the world and its resources (e.g. digital technology tools, appliances, implements)—readiness-to-hand and presence-at-hand—are applicable not only to concrete tools such as a hammer, but also to more complicated or abstract technology. In parallel to a carpenter who needs to hit nails with a hammer but finds the hammer to be missing or broken, a learner who is editing text with a piece of word processing software but does not find the needed function focuses their attention on the properties of the software or the keyboard instead of the writing.

Consequently, if the pieces of equipment used in our everyday activities are not objects with certain attributes but primarily integral parts of functions performed with them, then these functions are what we should consider in, for example, studying the use of digital technologies. The technologies make sense for the participants of the activity only in relation to the whole event that is unfolding in their particular social and material environment (Roth, 2007). Whereas there is a growing body of research on the various roles of digital devices that can support learning processes (e.g. Jeong & Hmelo-Silver, 2016; Rosé et al., 2019), few studies have empirically addressed the question of how the perceived and reported quality—functionality—of using the devices are connected to the efficiency of learning.
Next, we apply Heidegger’s categories of readiness-to-hand and presence-at-hand to operationalise two modes of relating to digital technology during learning processes, one that highlights the functionality and serviceability of the technology and a second that highlights the physical properties, deficiencies and challenges of the use of the technology. Incorporating data from students’ self-reported use of digital technology, related experiences and grades, we investigate a hypothesis that the commonly reported inefficient use of digital technology is connected to experiencing these technologies as present-at-hand—as mere objects—instead of the devices being ready-to-hand for their users.

2.1. Hypotheses

This study was designed to investigate the hypothesis that non-existent or negative correlations between reported digital technology use and academic achievement could be explained by the experience of using digital technology in non-functional ways. Based on the theoretical framework, we have formulated six hypotheses involving the two independent variables (present-at-hand digital technology and ready-to-hand digital technology) and two dependent variables (perceived frequency of digital technology use and academic achievement). Present-at-hand and ready-to-hand are two aspects of experiencing the use of digital technology in learning. Because the first refers to the non-functional use and the second to the functional use of digital technology for learning, experiencing one should not indicate the other. Therefore, the first hypothesis is related to the connection between these two independent latent variables:

- Hypothesis 1: Present-at-hand digital technology has no correlation with ready-to-hand digital technology.

As hindrances to using digital technology are experienced, the digital technology becomes visible, and the user concentrates on it. The next three hypotheses relate to the perceived (reported) time of using digital technology. We expect that, if students experience digital technology as hindering the learning tasks, they perceive that they are spending more time with digital technology. Experiencing the time spent using digital technology is related to interfered learning, and therefore, it is expected to have no impact on achievement, or even a negative impact:

- Hypothesis 2: Present-at-hand digital technology has a positive impact on the frequency of digital technology use.
- Hypothesis 3: Present-at-hand digital technology has a negative impact on academic achievement.
- Hypothesis 4: Frequency of digital technology use has no impact or a negative impact on academic achievement.

While a student is engaged in a task, their attention is not directed to the digital technology; the tool becomes a transparent part of the activity. Accordingly, we expect that the functional use of digital technology contradicts the experience of spending time with such technology:

- Hypothesis 5: Ready-to-hand digital technology has a negative impact on the frequency of digital technology use.

Finally, we expect that students’ experiences of achieving something and completing tasks with functionally used digital tools may indicate better concentration on the task and lead to higher achievement:

- Hypothesis 6: Ready-to-hand digital technology has a positive impact on academic achievement.

We apply Structural Equation Modelling (SEM) to test these hypotheses. Traditional methods such as factor analysis are explorative, while SEM is confirmatory by nature. Instead of focusing on correlation between two variables (or a sum variable with vanished error), SEM is a statistical method to test the hypothesised model and model multivariate relation to determinate to what extent the entire system of variables is consistent with the data (Byrne, 2016).

3. Methods

3.1. Instrument

The few existing attempts to empirically investigate Heidegger’s categories of readiness-to-hand and presence-at-hand are mainly found in the field of cognitive science (Dotov et al., 2010; Nie et al., 2011). For example, Dotov et al. (2010) investigated a problem-solving task with a computer and a mouse as a body–tool interface. The authors observed negative changes in mouse use during the moments of induced malfunctions, providing evidence for different cognitive behaviours during transparent use of equipment and equipment malfunctions. While we take a methodologically different approach, our operationalisation of the two categories in a questionnaire is also based on the effortlessness and fluidity of using the digital technology. Based on the theoretical understanding of ready-to-hand and present-at-hand digital technology, we generated several statements as possible items. After discussing and evaluating the items, we included in the questionnaire ten possible ready-to-hand items and ten possible present-at-hand items.

The items of ready-to-hand digital technology (functionality/serviceability) in the first instrument arise from the smooth operation of the educational technology when successfully attending to the given task (‘I am wrapped up in the task’; ‘I can’t stop engaging with
the task”); the student’s focus is targeted on making progress in the task (“I have a lot of good ideas”) and achieving the goal (“digi applications help me to make better output”).

In contrast, the items of present-at-hand digital technology (non-functionality) arise from the experienced interruptions of the task (“when I work with equipment, I find myself doing something else than what I should be doing”), malfunctioning tools (“the programme breaks down (crashes) suddenly”) and delays in performing the task (“I am waiting for the tool or application to start”). During these hindrances, attention is directed to the device or something that does not advance the task instead of the technology being a transparent part of the activity.

Based on Principal Component Analysis with varimax rotation, the ready-to-hand items loaded in two factors. Similarly, the initial present-at-hand items loaded in two factors. In both cases, it appeared that one factor was easier to interpret based on the theory. In both instruments, the selection criteria for the items were that the items were as general as possible. For example, items such as ‘I manage to produce text easily’ and ‘when I work with digital tools, it is difficult to produce text’ loaded in the excluded factors. Further, after the trials of SEM analysis, we excluded one item from both factors. Table 1 presents the descriptives of the two instruments—present-at-hand digital technology (non-functional use) and ready-to-hand digital technology (functional use).

For the frequency of digital technology use, we followed a PISA questionnaire (OECD, 2017). Previous literature (e.g. Chauhan, 2017) indicates that there are differences between subjects in digital technology use and achievement. Therefore, we asked students to report their experienced time for using digital technology subject-specifically (Table 1). However, instead of asking for daily use as in PISA with an overall estimate, we asked the students to examine their weekly use of digital technology in each subject. In Finnish middle school, teaching is highly subject-specific. For example, there is no integrated science, but separate subjects: biology, chemistry, (natural) geography, health education, and physics. Therefore, in order to keep the questionnaire as short as possible, we selected physics to represent science subjects and accordingly history to represent arts. Mother tongue and mathematics are the subjects with the largest number of weekly lessons and therefore natural selections in the questionnaire.

3.2. Data gathering

The study sample consisted of 203 middle school students (grades 7–9, age 13–16 years, 110 girls, 72 boys, 4 other, 17 did not indicate). In middle school in Finland, teaching is organised subject-specifically and conducted by subject teachers. Therefore, it is expected that students are more capable of distinguishing, evaluating and comparing their digital technology use subject-specifically. Further, we consider that students at the primary level are merely learning to use digital technologies, while in middle school they use digital technologies in learning subject-specific issues.

The data were collected in the autumn semester of 2020. Students were from a school located in the eastern suburbs of Helsinki, an area with mixed levels of socio-economic status. The teachers of the student group were instructed to organise the questionnaire answering during lesson time. Permission to participate in data collection was acquired from the students’ guardians; permission to administer the questionnaire was received from the school administration. The principle of informed consent was followed in the data.

Table 1
Descriptive statistics of the items.

<table>
<thead>
<tr>
<th>Item</th>
<th>N</th>
<th>Mean</th>
<th>St.D.</th>
<th>α</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Present-at-hand</strong></td>
<td></td>
<td></td>
<td></td>
<td>.65</td>
</tr>
<tr>
<td>While I learn with digital tools, I find that …</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d1) I am waiting for the tool or application to start</td>
<td>199</td>
<td>2.87</td>
<td>1.15</td>
<td></td>
</tr>
<tr>
<td>d3) I cannot find the needed function</td>
<td>202</td>
<td>2.07</td>
<td>.87</td>
<td></td>
</tr>
<tr>
<td>d5) the program breaks down (crashes) suddenly</td>
<td>201</td>
<td>1.83</td>
<td>.78</td>
<td></td>
</tr>
<tr>
<td>d8) when I work with equipment, I find myself doing something else than what I should be doing</td>
<td>200</td>
<td>1.90</td>
<td>.88</td>
<td></td>
</tr>
<tr>
<td><strong>Ready-to-hand</strong></td>
<td></td>
<td></td>
<td></td>
<td>.83</td>
</tr>
<tr>
<td>As I learn with digital tools, I feel that …</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d16) I have a lot of good ideas</td>
<td>199</td>
<td>3.39</td>
<td>1.04</td>
<td></td>
</tr>
<tr>
<td>d17) I am wrapped up in the task</td>
<td>198</td>
<td>3.43</td>
<td>1.04</td>
<td></td>
</tr>
<tr>
<td>d18) digi applications help me to make better output</td>
<td>198</td>
<td>3.33</td>
<td>1.05</td>
<td></td>
</tr>
<tr>
<td>d19) I can’t stop engaging with the task</td>
<td>195</td>
<td>2.34</td>
<td>.95</td>
<td></td>
</tr>
<tr>
<td><strong>Frequency of digital technology use</strong></td>
<td></td>
<td></td>
<td></td>
<td>.55</td>
</tr>
<tr>
<td>Estimate how much time you spend on learning with digital tools during the lessons (during the typical school week) in the following subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics</td>
<td>196</td>
<td>2.34</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Mother tongue</td>
<td>200</td>
<td>2.36</td>
<td>.95</td>
<td></td>
</tr>
<tr>
<td>Physics</td>
<td>180</td>
<td>2.31</td>
<td>1.05</td>
<td></td>
</tr>
<tr>
<td>History</td>
<td>140</td>
<td>1.95</td>
<td>.86</td>
<td></td>
</tr>
<tr>
<td><strong>Academic achievement</strong></td>
<td></td>
<td></td>
<td></td>
<td>.91</td>
</tr>
<tr>
<td>Your last grade in the school report</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics</td>
<td>196</td>
<td>8.72</td>
<td>1.09</td>
<td></td>
</tr>
<tr>
<td>Mother tongue</td>
<td>191</td>
<td>8.72</td>
<td>1.03</td>
<td></td>
</tr>
<tr>
<td>Physics</td>
<td>191</td>
<td>8.63</td>
<td>1.12</td>
<td></td>
</tr>
<tr>
<td>History</td>
<td>193</td>
<td>8.58</td>
<td>1.13</td>
<td></td>
</tr>
</tbody>
</table>

Note. The scale for present-at-hand and ready-to-hand items was as follows: 1) almost never, 2) seldom, 3) now and then, 4) often, 5) almost always. The scale for frequency of digital technology use was 1) never, 2) 1–30 min per week, 3) 31–60 min per week, and 4) over 60 min per week. The scale for students’ achievements in the school report is from 4 (fail) to 10 (excellent).
collection, and participation was voluntary.

3.3. Analyses

The relationships between the variables were analysed and hypotheses were tested by applying structural equation modelling (Byrne, 2016). Analysis was performed with IBM SPSS AMOS version 25. Maximum likelihood was used for estimating the parameters in the model. The indices root mean square error of approximation (RMSEA = 0.045), minimum discrepancy per degrees of freedom (CMIN/df = 1.403), and the comparative fit index (CFI = 0.959) indicate that the model fitted the data well (Byrne, 2016; Wheaton et al., 1977).

4. Results

Fig. 1 presents the structural equation model, which predicts the frequency of digital technology use (digi time) and academic achievement with the two developed instruments—present-at-hand digital technology and ready-to-hand digital technology. There were two statistically significant connections in the model: present-at-hand digital technology has an impact on the frequency of digital technology use (digi time), and ready-to-hand digital technology has an impact on academic achievement. Although the estimates indicate the expected direction in the other connections, they were not statistically significant. Table 2 shows a summary of whether the hypotheses were supported. However, the main result is as hypothesised: experience of non-functional use of digital technology has an impact on the perceived time used of digital technology, while experience of functional use of digital technology has an impact on academic achievement.

5. Discussion

The goal of this study was to investigate whether the experiences of the non-functional use of technology (present-at-hand digital
Computers & Education 176 (2022) 104361

K. Jumti et al.

Table 2
Summary of the results.

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Present-at-hand digital technology has no correlation with ready-to-hand digital technology.</td>
<td>Supported</td>
</tr>
<tr>
<td>2: Present-at-hand digital technology has a positive impact on frequency of digital technology use (digi time).</td>
<td>Supported</td>
</tr>
<tr>
<td>3: Present-at-hand digital technology has a negative impact on academic achievement.</td>
<td>Supported</td>
</tr>
<tr>
<td>4: Frequency of digital technology use (digi time) has no impact or a negative impact on academic achievement.</td>
<td>Supported</td>
</tr>
<tr>
<td>5: Ready-to-hand digital technology has a negative impact on digital technology use (digi time).</td>
<td>Not supported</td>
</tr>
<tr>
<td>6: Ready-to-hand digital technology has a positive impact on academic achievement.</td>
<td>Supported</td>
</tr>
</tbody>
</table>

Technology (technology), in which the students’ attention is targeted towards the device rather than completing the task, can explain why large-scale surveys struggle to find a positive correlation between the quantity of educational technology use and academic achievement (e.g. OECD, 2015; Skryabin et al., 2015). Whereas the quality of using digital technologies in schools is considered an essential factor for learning (e.g. Lei, 2010; Tamim et al., 2011), most large-scale studies merely measure the self-reported time or frequency of (various) technology uses. More sophisticated ways are needed to measure students’ ICT use in large-scale studies (Hu et al., 2018). In this study, we showed how the experienced non-functional use of (present-at-hand) educational digital technology explained the reported high time spent using technology. In addition, we showed that the experienced functional use of (ready-to-hand) digital technology explained higher academic achievement. Our results suggest that students who report frequent use of technology tend to experience more non-functional use, which could explain the negative impact on learning in large scale surveys.

To explain the observed impact, we return to Heidegger’s (1962) notions of the everyday use of appliances. Ready-to-hand equipment tends to become a transparent part of the activity, and the user’s attention is directed primarily to its function and serviceability in order to do something. In contrast, when the activity is interrupted for some reason arising from the equipment (e.g. malfunction regarding the task), the user’s attention is directed towards the technology as a present-at-hand object. We suggest that the students who report a higher quantity of technology use may have had more non-functional experiences of the technology as present-at-hand than those who report less technology use. These students may have more problems in learning tasks with technology, and more of their focus (time) might be targeted at the technology rather than completing the task and learning. They may lack basic skills in using software and struggle to find the needed function in word processing software, the computers may be old, and the students may have to wait for the applications to start. In contrast, the observed positive impact of the functional experiences of technology use on achievement can be explained by the higher degree of using ready-to-hand digital technology for learning. In such use, the technology can even be integrated as a transparent part of the activity, such as writing and editing text with a familiar word processor, using thermal cameras in physics or reading digitalised archive documents in history. The findings of the study suggest that students who have more experience of technology as a transparent part of their learning may achieve their learning goals better, but they may report less technology use because they are thinking about the task rather than the technology used.

Researchers have attempted to overcome the challenge of capturing the quality of educational technology use in large-scale surveys by calculating separate effect sizes for different technologies or subjects (e.g. Chauhan, 2017; Cheung & Slavin, 2012, 2013; Hattie, 2008). Fernández-Gutiérrez et al. (2020) highlighted that, in science, there are more opportunities for advantageous uses of digital technology than maths or reading. While implementing digital technology in school, it is important to remember that lower-achieving students may experience difficulties in engaging in learning activities (Bergdahl et al., 2020). Thus, the question of the role of digital technology in student performance comes back to the quality of using it. However, we suggest that, to better measure the quality of technology use, it might be more important to focus on the quality of time spent with the technology rather than different technologies or what they are used for. Here, the present findings are in line with previous studies, which suggested that positive experiences (reflected in positive attitudes) while using the technology (Petko et al., 2017) or high perceived engagement with technology (Bergdahl et al., 2020) could explain the impact on achievement. The experience of functional use of technology explored in this study may well be connected to positive experiences of or engagement with educational technology. But whereas the previous studies investigated the experience of technology use indirectly through attitudes or perceived engagement—something which can be discordant with the actual application of technology (Lee et al., 2019)—the present study explored more direct ways to measure the self-reported quality of the process of technology use.

The instruments developed in this study that measure the functionality and non-functionality of educational technology can be considered an attempt to measure how the actual use of the devices is experienced instead of perceptions of the devices or their (dis)advantages. We suggest that these instruments work and can be developed as a viable alternative for reporting (estimating) the time or frequency of using different technologies for different purposes. Further studies, preferably with longitudinal data or experimental setups, are needed to further test the validity and reliability of these instruments in capturing the (lack of) serviceable and meaningful use of educational technology. As more research is needed in general to understand and harness the potential of digital technologies in supporting learning and transforming education (e.g. Stahl & Hakkarainen, 2021), our articulation of the functionality of technology may work as a viable perspective for a wide range of empirical studies. For example, future large-scale survey studies might find a positive correlation with the functional use of digital technology and learning, whereas the commonly investigated frequency of technology use may correlate with non-functional use.

This study may improve approaches to measure the self-reported quality over quantity of using educational technologies. However, some limitations related to the self-reported data remain. The time of technology use, as well as grades, were self-reported by the students. Although we have questioned the validity of self-reported time to truly measure the functional and efficient time of
educational technology use, the self-reported time that is used in this study was the only valid variable to test this hypothesis. Concerning the grades, our assumption is that the students have remembered their grades and reported them accurately because there is no obvious reason for them to do otherwise in a questionnaire. Further, it is known that self-reports are not very well associated with actual behaviour (Jacoby, 1978).

Our approach was to test hypotheses that experience of non-functionality of digital technology explains the high self-reported frequency of using such technology. Our aim has been to develop instruments that capture the experienced ways of using the devices instead of students’ attitudes or estimated outcomes. While the limitation of self-reported measures—such as social desirability bias (e.g., Lajunen & Özkan, 2011)—remain, we believe our instrument to be an improvement in reporting the experienced quality of technology use in learning. Nevertheless, future (experimental) studies are needed to further investigate the relations between the observed time spent using educational technology, the observed functionality of the technology, and the self-reported accounts regarding these two topics.

Finally, the present study showed that the functional and serviceable use of educational technology—manifesting as successfully attending to the task—can benefit academic achievement. Whereas we approached the functional use of educational technology at a general level, we acknowledge that what is functional often depends on learning goals that are specific to the discipline, as well as to the task at hand (Roth, 2020). For example, if the subject-specific goals of digital technology use emphasise collaborative activities rather than individualised ones, researchers might want to focus on the measurement of functional collaborative use in particular instead of exploring students’ general experiences or perceptions of technology use (cf. Lee et al., 2019). All in all, our findings encourage educators to identify practices where the use of technology is an integrated and transparent (Ihde, 1976) part of the general experiences or perceptions of technology use (cf. Brown et al., 2010). Such authentic discipline-specific uses of digital technology could include, for example, data logging and molecule modelling in science subjects, digital document archives in history, modelling and symbolic calculation software in mathematics, and collaborative knowledge creation practices with cloud services and communication platform applications in languages and literacy. Applying such practices may require more time to learn to use the specific technology and to rethink the aims and assessment criteria. However, such learning activities in particular may enable and encourage the students to focus on processes that are relevant to learning goals in the task at hand rather than on the devices.

Credit author statement

KJ: Original idea, research design, instrument design, data analysis, writing. AK: research design, Instrument design, writing. AL: research design, Instrument design, data curation, writing.

References


