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Teachers' Classroom Digital Technology Integration Practices

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Abstract: Classroom digital technology integration (CDTI) is increasingly common to facilitate technology-enhanced learning. However, in the Estonian context, there is a lack of understanding of the CDTI's practices that is yet necessary to evaluate the effect of purposeful CDTI to provide research-based advocation for CDTI. Our study aims to contribute to the field by identifying Estonian basic education teachers' practices regarding CDTI, considering the use of digital technology and its purposes. To that end, we conducted in-class observations of basic education teachers' lessons to note the use of digital technology. We analyzed the observed uses based on the Substitution, Augmentation, Modification and Redefinition (SAMR) model. Furthermore, we interviewed the teachers to understand their purposes for the DTI and categorized the given explanations by categories of technology-enhanced learning. We conducted cluster analyses to identify the types of practices that we then described and compared. We identified four types of teachers' practices: introducing, facilitating, motivating, and deepening, which differed in the purpose and use of digital technology in instructional processes. These results make way for evaluating the effect of different practices on learning outcomes.

Keywords: classroom digital technology integration, basic education, SAMR, technology-enhanced learning, technology-enhanced teaching

1. Introduction

Classroom digital technology integration (CDTI) is prominent in modern society and education. Previous research suggests the pandemic created an opportunity for educational innovations previously proposed but not fully implemented, advocating for a need to reimagine post-COVID-19 education using technology (Zhao & Watterston, 2021). Due to digital technology's learning affordances, education policies support the integration of digital technology in education (e.g., OECD, 2020). For example, Estonia, a digital forerunner, has set developing and implementing digital pedagogy as a future education goal (EMER, 2020). Digital readiness is high among Estonian teachers (e.g., Karaseva, Pruulmann-Vengerfeldt, & Siibak, 2013, 2017), and the Estonian teacher's professional standards framework emphasizes the use of digital technology in teaching and learning (Pedaste et al., 2019). As Estonia is one of the top-performing education systems (OECD, 2020), it may be beneficial to delve deeper into this context to shed light on the CDTI's effect on learning outcomes.

Estonia's K-12 curriculum gives teachers considerable autonomy in facilitating content (Tire, 2021). This autonomy contributes to teachers' agency (Ketelaar et al., 2013), making way for ownership (Godfrey & Olson, 2019), which is necessary to implement innovations successfully (Ketelaar et al., 2013). To increase ownership, decision-making should include stakeholders, as in Estonia, where teachers have direct input on educational policies (Gabriel et al., 2022). Further, students are increasingly involved in creating educational experiences under the paradigm of contemporary learning (EMER, 2020). In this paradigm, students are at the centre of learning design and instruction to scaffold their agency, keeping in mind the need for independent and self-regulated learners in a rapidly changing, uncertain world (Sum, Chan, & Wong, 2021). Previous research links co-constructivist practices alike to CDTI (Admiraal et al., 2017). Indeed, under the theory of technology-mediated learning, it is crucial to recognize the role played by the stakeholders in influencing the CDTI (Bower, 2019). According to previous studies, teachers are the primary agents determining the CDTI (Liu & Chao, 2017), so studying teacher practices is the key to understanding the phenomenon. A 2013 qualitative study in Estonia identified CDTI teacher CDTI practices practices in relation to subjects and

instructional styles (Karaseva, Pruulmann-Vengerfeldt, & Siibak, 2013). Due to the complex relationships between CDTI practices and learning outcomes, they should be considered interwoven with various factors, including purpose (Fawns, 2022), giving way to an understanding of teachers' pedagogical stance and its role in mediating learning (Aubrey-Smith, 2021). To contribute to the latter, our study seeks to get insight into teachers' CDTI practices and is thus guided by the following research question, what are teachers' digital technology integration practices regarding the use of digital technology and its purpose in the instruction?

2. Background

One of the most used frameworks for describing digital technology integration is the Substitution, Augmentation, Modification, and Redefinition framework (also known by its acronym SAMR), first proposed by Puentedura (2006). For SAMR's refined amalgamation of other frameworks and its popularity among researchers and educators (e.g., Crompton & Burke, 2020; Tlili et al., 2022), we will also base our study on the SAMR framework. SAMR framework describes CDTI in four levels: Substitution, Augmentation, Modification, and Redefinition. Substitution refers to learning activities that can be done with and without technology as it does not afford any functional change in the task, e.g., infinity canvas. Augmentation represents the use of digital technology in which there is a functional improvement in the learning task, e.g., automated control. Modification indicates an alteration of the learning task made possible due to the CDTI, e.g., computer simulations. Redefinition allows for a new learning task that could not be accomplished without integrating digital technology, e.g., hybrid learning.

Despite the model's representation in levels, none of the types of use is superior to one another, as meaningful CDTI depends on the learning objectives (Hamilton, Rosenberg, & Akcaoglu, 2016). As agentic intentions are considered of humans and not technologies (Bower, 2019), meaning digital technologies' affordances and CDTI practices are user-dependent (Aubrey-Smith, 2021), it is important to consider the CDTI's underlying purposes, which helps understand the connection between the CDTI and learning outcomes and variables mediating it. As the aims of the CDTI are not considered in the SAMR model, our study combines the SAMR model with the three ways digital technology enhances teaching and learning processes proposed by Kirkwood and Price (2013) in their meta-analysis. First, operational improvement concerns more flexibility or efficiency, e.g., e-books are faster to navigate than printed books. Quantitative changes refer to increased student involvement, time spent on task, and positive attitude, e.g., gamification. Third, qualitative change indicates facilitating higher-order thinking, critical awareness, and deeper understanding, e.g., using digital technologies as tools for reflection.

3. Methodology

3.1 Sample

The study has a purposeful sample of Estonian 3rd, 6th and 9th-grade teachers of Estonian, mathematics, and natural sciences. The teachers were chosen based on the profiles of the schools they worked at. The schools were selected purposefully to have a broad representation of schools considering the following: students' academic and digital competence tests, the school's self-assessment of digital competence and the school's result in the school satisfaction survey. Teachers' participation in the study was voluntary. In total, 93 teachers, of whom 24% were 3rd grade, 39% 6th grade, 24% 9th grade and 14% 6th and 9th-grade teachers from 13 different schools, participated in the study. Amongst the total, 76% of 6th and 9th-grade teachers, 28% were Estonian language teachers, 44% mathematics and 28% natural sciences teachers. Usually, the same 3rd-grade teacher teaches the Estonian language, mathematics, and natural sciences in Estonia.

3.2 Data Collection

Seven purposefully trained researchers observed in-class lessons and interviewed teachers who used digital technology in their lessons. Each subject (Estonian, math, natural sciences) lesson was observed once in each grade (3rd, 6th, 9th). The lessons were chosen randomly because we were interested in how digital technology is used in the everyday classroom, not in a specifically prepared situation of CDTI. In total, 169 lessons were observed, of which 82% included CDTI. These lessons included 269 different learning activities with the use of digital technology. During observations, we noted down descriptions of who used what digital technology and how. We conducted immediately after the observations semi-structured interviews soliciting answers to a question about why digital technology was used in the lessons. During the interviews, meaningful utterances were noted down for coding later.

3.3 Data Analysis

The data were analyzed under the SAMR model and the categories of purposes of digital technology integration (i.e., operational improvement, quantitative and qualitative change). Besides these deductively coded dimensions, researchers were opened to other categories that might emerge inductively as the theoretical underpinnings of our study had not been previously used in combination in the K-12 context in Estonia. Each teacher's observational and interview data were used to create a string of binary codes of the considered dimensions to describe the teacher's practice. Code 0 was attributed when the dimension was not present, and code 1 when it was present. Descriptions of events relating to the use of digital technology were noted during observations and then encoded according to the SAMR framework. Relevant utterances of the interviews were noted down and then coded according to Kirkwood & Price's (2013) categories for using digital technology to support teaching and learning: operational, quantitative, and qualitative. For inter-rater reliability, we used Fleiss Kappa, which allows considering more than two raters. The Kappa was 0.79, indicating acceptable reliability.

To identify types of teacher practices in the use of digital technology, we ran hierarchical clustering using Ward's method to identify clusters in which the dispersity within a cluster would be minimal but the diversity between the clusters maximal. The number of clusters and cluster centroids were determined from the dendrogram and further optimized with K-means cluster analyses. Clusters were validated by first checking clusters' stability by replicating the analysis by randomly dividing the sample into two halves and considering clusters' meaningfulness through ANOVA analysis, indicating variation between sample means and eta squares, showing which variables distinguish the clusters the most. The identified clusters were described and compared using means to find the statistically and meaningfully best fitting cluster model. All the statistical tests were done using the program SPSS version 28.0.

4. Results

We performed a deductive analysis of teachers' CDTI practices in relation to the use of digital technology based on the SAMR framework and purpose under the technology-enhanced learning and teaching categories proposed by Kirkwood and Price (2013). All the sub-dimensions of use and purpose were present in our data. Furthermore, we identified one additional category, namely sustainability. Although all the sub-dimensions were present, the level of their occurrence varied considerably. Regarding digital technology, uses on the Substitution and Augmentation level were markedly more prominent than on the Modification and Redefinition level. Considering the purposes of digital technology integration, categories of technology-enhanced teaching were considerably less common than categories of technology-enhanced learning.

Based on hierarchical clustering of teachers' CDTI practices and cluster comparison by ANOVA analysis, we identified four different teachers' practices, named as follows: facilitating, motivating, deepening, and introducing. All four practices differ in their use and purpose, while differences in the latter seem the most prominent. Differentiations relating to use appear mainly on the Augmentation level but somewhat also in use on the Substitution level. The objectives of CDTI differ mainly regarding student-centred purposes (see Figure 1).

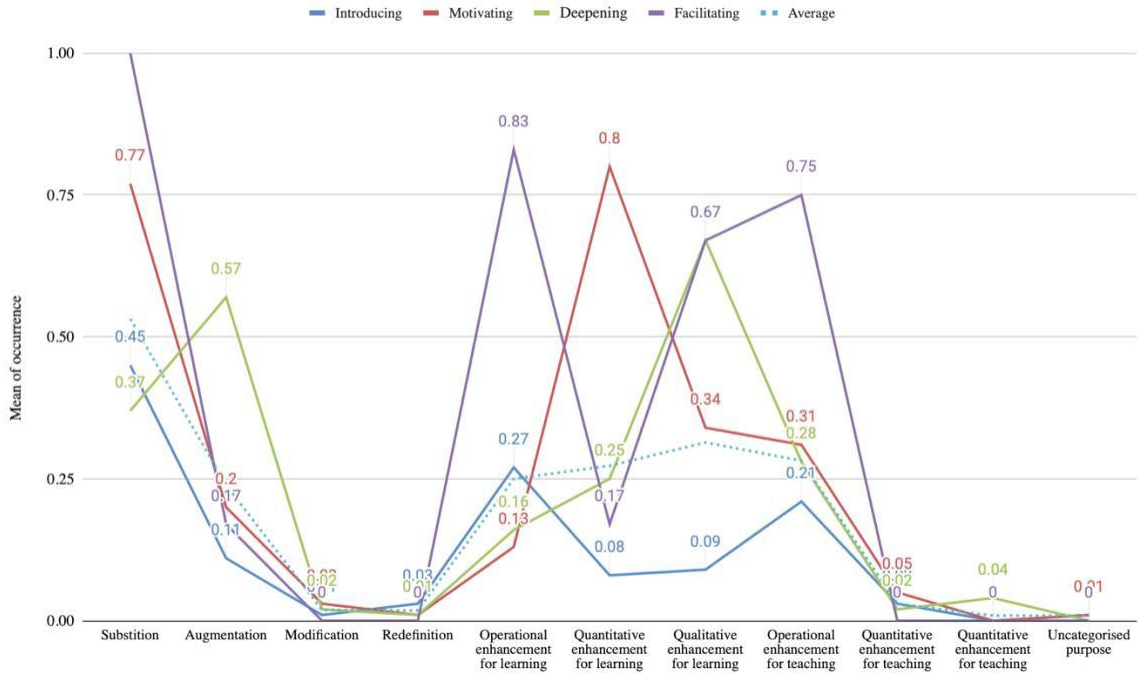

Figure 1. Teacher practices in classroom digital technology integration.

The CDTI is the most varied amongst deepening practices, using it for Substitution and Augmentation, the latter being most prominent. Deepening focuses mainly on CDTI's different affordances for the qualitative enhancement of learning. Facilitating, motivating, and introducing practices use technology mostly, although with different regularities, for Substitution, but their purposes differ. More specifically, facilitating stands out from the others regarding the purposes of operational enhancement of teaching and learning and qualitative enhancement for students, i.e., facilitating the teaching-learning processes while keeping in mind in-depth learning. On the other hand, motivating practices focus mainly on quantitative enhancement for students, such as motivation and engagement. The use of digital technology is the least common practice among introducing, and it is primarily without a specific aspect of enhancement in mind when doing so.

The variable that distinguishes the clusters the most is a quantitative enhancement for learning (60.3%), followed by qualitative enhancement for learning (46.7%), use of digital technology on the Augmentation level (41.9%) and operational improvement for learning (20.3%). The values of these variables were also statistically significantly different in describing variation between means based on ANOVA. A somewhat prominent distinguisher (12.5%), operational improvement for teaching is close to being a statistically significant variable in variations. Digital technology uses on the levels of Modification and Redefinition, quantitative and qualitative enhancements of teaching, and uncategorized enhancement, to distinguish the clusters minimally (between 1.1% and 6.9%). These variables were also not statistically significantly different in describing variations between clusters. Reasons for this might be their low occurrences in the data set (less than 2.5% of the cases). Hence, these variables were left out for describing and comparing clusters.

5. Discussion & Conclusion

Our study aimed to identify types of Estonian basic education teachers' classroom digital technology integration practices considering the use of digital technology under the SAMR model (Puentedura, 2006) and CDTI's purpose in the instruction as suggested by Kirkwood and Price (2013). From the data, an additional purpose for the CDTI emerged, namely, sustainability, aligning with the transformative concept, e.g., technology-mediated, sustainable education necessary for supporting continual coexistence with other ecosystems (Burns, 2018). Although all the sub-dimensions of the SAMR framework were noted, uses on the Modification and Redefinition level of CDTI were far less

common than uses on the Substitution and Augmentation level. The latter is a possible indicator that Estonian teachers use CDTI mainly to replicate and supplement existing practices rather than transform them.

Within these general tendencies regarding teachers' CDTI practices, our study identified four practices: introducing, facilitating, motivating, and deepening. In introducing, facilitating, and motivating, CDTI is mainly used for Substitution, although with different regularities; in deepening practices, CDTI is also used for Augmentation, yielding in more varied use of CDTI. Deepening practices focus more on qualitative enhancement, e.g., facilitating the teaching-learning processes and learning opportunities for students. Qualitative enhancement is also a significant catalyst for practices of facilitating alongside a more protruding focus on operational enhancement. Motivating practices focus on quantitative enhancement, e.g., motivating and engaging. Introducing practices where technology is used in less than half of the events has no strong specific purpose for CDTI.

Hence, these practices differ in the purpose and use of digital technology in instructional processes, while the first is more protruding in differentiating the clusters. This discrepancy may be explained by purposes serving as a more robust insight into teachers' pedagogical stance than mere uses (Aubrey-Smith, 2021); however, a connection between those has also been noted (e.g., Admiraal et al., 2017). These results suggest that teachers' knowledge and skills alone may not be enough to support meaningful technology use in learning. Teachers also need to have a clear understanding of the purposes of CDTI. The latter is not easily developed in traditional in-service training but needs to be discussed among groups of teachers as they act as primary agents in CDTI (Liu & Chao, 2017).

Further, it is worth noting that regarding the purposes of the CDTI, student-centred purposes were considerably more prominent than teacher-centred purposes, implying that Estonian teachers' practices, and thus possibly their pedagogical stances (Aubrey-Smith, 2021), focus on students. Furthermore, as the teachers who focused more on student-centred purposes were the teachers with more frequent or varied practices of CDTI, our results align with previous findings that indicate a connection between teachers' technology practices and co-constructivist teaching approach, i.e., approach where learning builds on a dialogue between teachers and students or peers (Admiraal et al., 2017), which might be an indicator of the relative success behind Estonian educational system, taken that Estonia excels in academic achievement in international tests like PISA (OECD, 2020).

The results of our study might serve as valuable information to support stakeholders in developing and implementing CDTI. More specifically, the practical implications of our study are threefold. First, to support meaningful and effective CDTI, we suggest offering tailored support and training to the teachers considering their prominent type of CDTI practice rendering, thus the support most beneficial for them. Second, considering teachers' practices may give way for more meaningful dialogue between teachers and developers of educational technology so that this technology would be knowledgeably designed for empowering teachers and students in the teaching-learning processes whilst being considerate of relevant challenges in the domain, including teacher's practices and pedagogical stances that mediate these. Third, the results of our study may serve as a starting point for studying the impact of different CDTI practices on students' learning outcomes. Therefore, it constitutes commencement for research into the advocation for meaningful uses of digital technology where the use is planned based on the learning objectives while considering the ways digital technology can facilitate the learning process for different kinds of students.

Finally, we also acknowledge some limitations in our study. First, our study did not consider possible reasons behind the identified practices, which could support the meaning-making of the practice and thus also the teachers' pedagogical stance. For example, we could consider the following factors influencing the CDTI practices: contextual variables and teacher-specific characteristics such as perceptions of the CDTI. Second, the types of practices were identified based on means. Yet, within the practice types, there may be teachers who are not comparable to the other teachers in the same cluster regarding all the variables. Therefore, future research is needed to collect further data on possible related factors of the identified practices to underpin sense-making and increase the trustworthiness of the results by conducting cluster analysis and latent profile analysis, combining it with member checking.

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