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Integration of educational technology during the Covid-19 pandemic: An analysis of teacher and student receptions

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Abstract: This study analyzes the integration of an educational technology platform and relates the difficulties faced amidst the Covid-19 pandemic. Initially, we sought to identify the chief barriers educators face when considering the adoption of Information and Communication Technology (ICT). Factors influencing primary and secondary education teachers' (n = 15) and students' (n = 335) perspectives on ICT integration for mathematics instruction were identified and analyzed from the perspective of different contexts (school vs home) and circumstances (in-person vs remote learning). Although we acknowledge the need for immediate decisions by educational stakeholders to facilitate online learning, our findings indicate the necessity of (a) careful examination of the features of potential platforms or tools and (b) a trial of such features prior to integration within an educational system. From an instructional design perspective, educational technologists should pay special attention to the degree of gamification, especially beyond the primary school level, as it may negatively impact incentives for student interaction and engagement. Where possible, the integration of technology should be driven by pedagogical goals and not technological pressures.

ABOUT THE AUTHOR

Athanasios Christopoulos (Ph.D., Computer Science) is a Research Fellow in the Department of Computing at the University of Turku, Finland. Dr. Christopoulos is currently working for the Centre for Learning Analytics where he investigates matters related to digital inclusion, educational technology advancement, immersive technologies and learning analytics. The Centre is also developing *"ViLLE"*, a digital learning platform that includes content and exercises for studying mathematics, programming, and languages (Finnish, English).

Pieter Sprangers (Doctoral candidate in Educational Design) has over 25 years of experience in teaching, educational design, and educational leadership both in Secondary and in Higher Education Institutions. Besides his teaching duties, his research activities in the domain of "scientific educational design research" focus on the redesign of educational systems.

PUBLIC INTEREST STATEMENT

Integration of digital learning tools, across different contexts and cultures (i.e., countries other than the source), comes with several barriers and obstacles. The authors of this article report the findings of the first empirical study in Belgium (Flanders region) set to explore teachers' and students' perception toward the digital transformation of mathematics education (primary and lower secondary school level) and its potential to facilitate instruction during the Covid-19 pandemic outbreak. The outcomes of this work validate, alter, and enhance the existing body of knowledge while also providing insights and implications that relate to the integration of educational technology especially in challenging times.

Subjects: Mathematics Education;; Information & Communication Technology;; ICT;; Teacher Training

Keywords: Technology-enhanced learning; mathematics education; gamification; intelligent tutoring systems; primary school; secondary school

1. Introduction

The increasing growth of Information and Communication Technology (ICT) in education has prompted studies measuring the impact of technology on learners' motivation, performance, and engagement (Christopoulos et al., 2018). However, multiple efforts (Mayer, 2019; Zhu & Urhahne, 2018) highlight the need to help school principals and teachers orchestrate available digital learning resources.

Researchers have generally attributed the limited implementation of educational technology—inside and outside the classroom—to at least one of the following factors:

- an inability of teacher education programs to build technical knowledge and skills (Fishman & Davis, 2006)
- a lack of funding and resources (Nikolopoulou & Gialamas, 2015)
- an absence of direction related to e-course design and delivery (Vongkulluksn et al., 2018)
- limited motivational incentives (Scherer et al., 2019)

Although *first-order barriers* (e.g., funding, equipment, technical support, training) are crucial in determining the successful integration of technology in schools (Inan & Lowther, 2010), *second-order barriers* (e.g., teachers' beliefs, confidence, attitude, skills) may play an equally crucial role. However, limited research expressly targets the latter set of barriers (Ghavifekr et al., 2016; Scherer et al., 2019), and even fewer studies examine these topics in recent circumstances (Francom, 2020).

The Covid-19 pandemic flooded conventional teaching practices with additional concerns and constraints. Reich et al. (2020) identified the following themes:

- *Student motivation*: Teachers struggled to motivate students via computer screens.
- *Professional loss and burnout*: Without familiar means of teaching, instructors' sense of self-efficacy and professional identity were affected.
- *Exacerbated inequities*: Perceived loss deepened as teachers witnessed the intensification of the societal inequalities shaping their students' lives.

From a student perspective, five motivational positions within the continuum of self-determination (from non-self-determined to self-determined) have been identified: external regulation, introjected regulation, identified regulation, integrated regulation, and intrinsic regulation. These positions affect learners' dedication and engagement with the learning process. However, during the recent lockdown period, students were often unable to self-regulate their learning practices due to the lack of extrinsic reinforcements, guidance from the teacher, and support from their peers (Radha et al., 2020). As a result, their academic progression was mainly affected by their personal interest in learning, their self-determination to advance, the value they attributed to digital learning activities, and the enjoyment or satisfaction that digital learning tasks could offer.

2. Purpose of the study

Habibi et al. (2021) considered the additional challenges that the COVID-19 pandemic outbreak posed and updated the aforementioned list by including two additional barriers: the domestic barriers and the community barriers. All these challenges (i.e., school level barriers, curriculum level barriers, technological barriers, financial barriers, individual/personal barriers, domestic/community barriers) highlight the need to identify structured and research-based solutions that can facilitate the rapid integration of modern educational technologies in multifaceted learning settings (e.g., distance, face-to-face, blended) and support educators and students in achieving their professional and personal goals.

Therein, this study investigates the elements that relate to technology adaptation primarily from the teachers' and secondarily from the students' perspective as the latter (i.e., students) are less capable of making sharp decisions and/or facilitating conceived decisions related to their educational empowerment and advancement. To this end, mathematics is considered to be one of the school subjects that has traditionally been challenging for educators to teach and students to grasp (Anderson et al., 2020). In the meta-analysis that Benavides-Varela et al. (2020) have conducted, the impact of Technology Enhanced Learning (TEL) interventions was correlated significantly with learners' performance and even more so in cases where the students have demonstrated the presence of mathematical disabilities. The authors (*ibid*) place particular emphasis on the aspect of instructional design and the nature of the instructional strategies that are utilised, especially in digital-based interventions. In the present study, we explore these conclusions further by integrating an Intelligent Tutoring Systems (ITS[1]) in an effort to promote students' motivational incentives and facilitate the learning process.

To this end, the research question that this study sets out to answer is:

Which factors influence elementary and lower-secondary school teachers' and students' attitudes toward the adoption of technologies for mathematics education in different contexts (school vs home) and circumstances (contact vs remote teaching)?

3. Background

3.1. Technology-enhanced learning

Reich (2020) distinguishes the following genres of TEL: instructor-guided, algorithm-guided, and peer-guided. Algorithm-guided educational systems and tools have a longer history, and their evolution has been incremental. However, studies of adaptive tutors, especially in primary and secondary education, have not always demonstrated a positive impact (e.g., efficiency, efficacy) on learning—except for mathematics (Reich, 2020).

Drijvers (2013) identified the pedagogical design of the tools, the role of the educators, and the educational context as the most influential factors governing the integration of technology in primary and secondary education settings. These parameters point toward the radical change needed within the modern educational system, positioning teachers as information brokers and facilitators of learning and students as independent actors in pursuit of learning.

Nevertheless, it would be naïve to assume that learners will use educational technology autonomously and independently in the pursuit of uniformly positive learning gains (Nh & Nicholas, 2013). To achieve effective protocols related to the integration of educational technology (Farjon et al., 2019), educators need practical support to overcome technology incorporation barriers and professional development resources to design pedagogically informed instructional content tailored to the curriculum (Hoyles, 2018; Svela et al., 2019).

3.2. Computers in mathematics education

Because mathematical understanding grounds the development of STEM competencies, recent research has called for novel ways to integrate digital learning systems in math courses (Anderson et al., 2020). Systematic reviews on the empirical use of innovative solutions for mathematics education have highlighted instructional technology as a mediator of learning (Bray & Tangney, 2017). To this end, Nattland and Kerres (2009) differentiated digital learning/practicing systems into tutoring systems, intelligent tutoring systems, hypermedia systems, drill-and-practice programs, and simulations.

Regardless of the application type, the main objective for educational technological efforts remains the same—to promote optimal knowledge development and understanding. Nevertheless, the mere use of technology does not necessarily transform the learning experience (Li & Ma, 2010). Therefore, an investigation of how digital learning tools can be integrated within the modern educational system and how such integration influences the established practices remains an open issue.

3.3. Intelligent tutoring systems

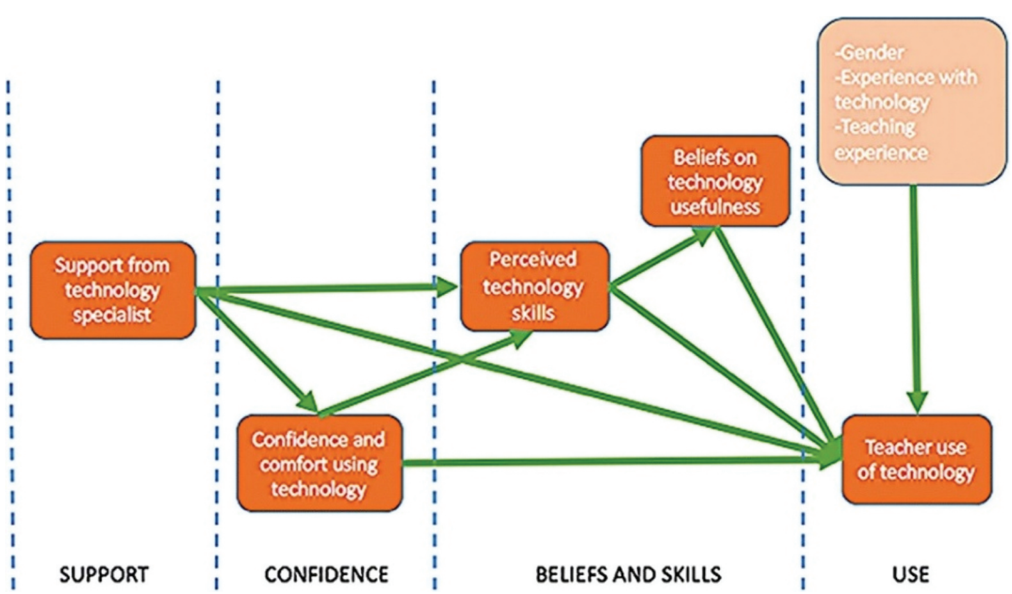
Computer-based instruction has yielded positive results in areas such as student motivation (Turk & Akyuz, 2016), satisfaction (Özyurt et al., 2014), performance (Ma et al., 2014), and learning outcomes (Van der Kleij et al., 2015). These results have been mainly attributed to the autonomy learners can exercise in making decisions, as well as the methods that develop competencies and capabilities (e.g., practicing until mastery is reached, in-depth exploration of mathematical expressions) (Hegedus et al., 2015).

In light of these findings, researchers explored the potential of applying Artificial Intelligence (AI) to digital instruction, converting digital tutoring systems into "Intelligent" Tutoring Systems capable of offering immediate, customized, instruction and feedback to learners without the presence of a teacher (Goodkovsky, 2004). Relevant systematic reviews and meta-analyses (Li & Ma, 2010; Ma et al., 2014; Steenbergen-Hu & Cooper, 2014) have found positive overall effects on the potential of ITS to provide adaptive, personalized learning pathways thus, recommending the conduct of continues research to improve and advance such technologies further.

4. Theoretical framework

Tondeur et al. (2017) recommend examining the integration of educational technology as a multifaceted and interconnected factorial system. Thus, we adopted the model proposed by Dogan et al., as demonstrated in Figure 1, and examined teachers' attitudes toward the

Figure 1. Factors influencing the integration of technology in education



integration of educational technology under different conditions (school vs home) and circumstances (contact vs remote teaching).

4.1. Instructor confidence and proficiency with technology

Teachers are the mediating agents of educational reform implementation. Their perceptions of a certain technology can promote or impede the adoption of ICT tools inside and outside the classroom. Thus, researchers have studied educators' self-efficacy (i.e., their self-rated ability) in applying technology to instruction. The results have shown a mostly positive—although not always direct—correlation between teachers' attitudes and confidence in using technology and its effective integration.

4.2. Support from technology specialists

Studies exploring the impact of expert support on technology integration have shown mixed results. For instance, Ritzhaupt et al. (2012) found that the technical coordination and overall support offered to teachers by technical staff had a direct (positive) effect on the technology integration. Razak et al. (2018) did not detect any significant difference in this area. Inan and Lowther (2010) reported a positive but indirect correlation between the perceived usefulness of technical and pedagogical support received by teachers during their pilot study. These conflicts highlight the need to anticipate the specialized support teachers require and its delivery.

5. Materials and methods

5.1. Research context

Regional schools (n = 14) in Belgium were invited to this initiative, and four expressed interest. Due to the study's technological focus, some degree of maturity was required to ensure student understanding of the integrated ITS functions and directions (detailed below); therefore, primary (fifth and sixth grade, 11–12 years old) and secondary (seventh and eighth grade, 12–13 years old) students participated. Students from higher grades were not selected out of an abundance of caution, as a long-term intervention might affect their graduation grade.

Figure 2. Examples of exercises in primary and secondary education.

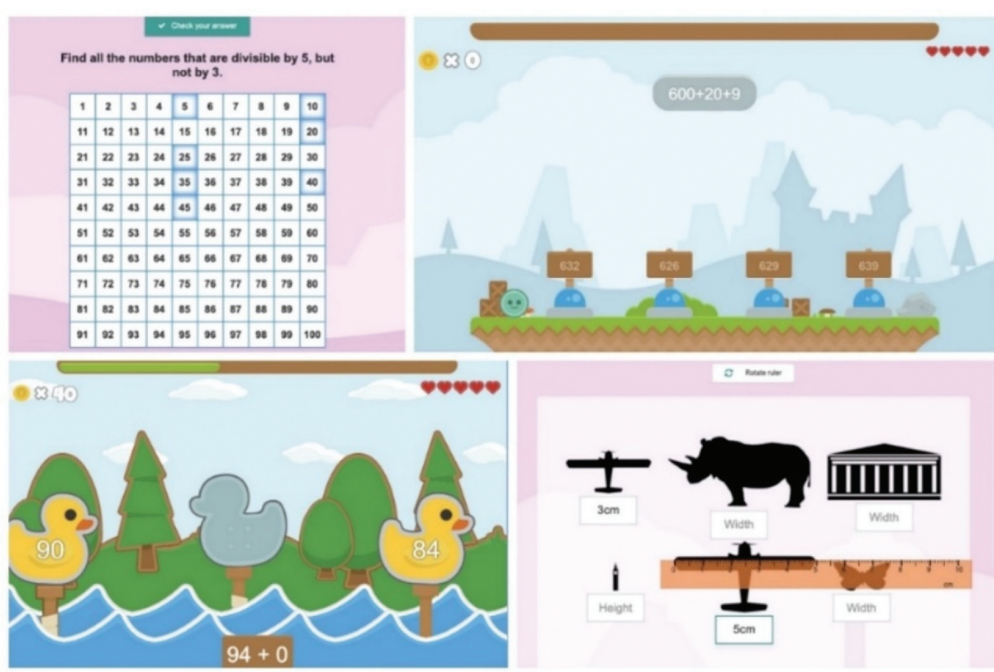
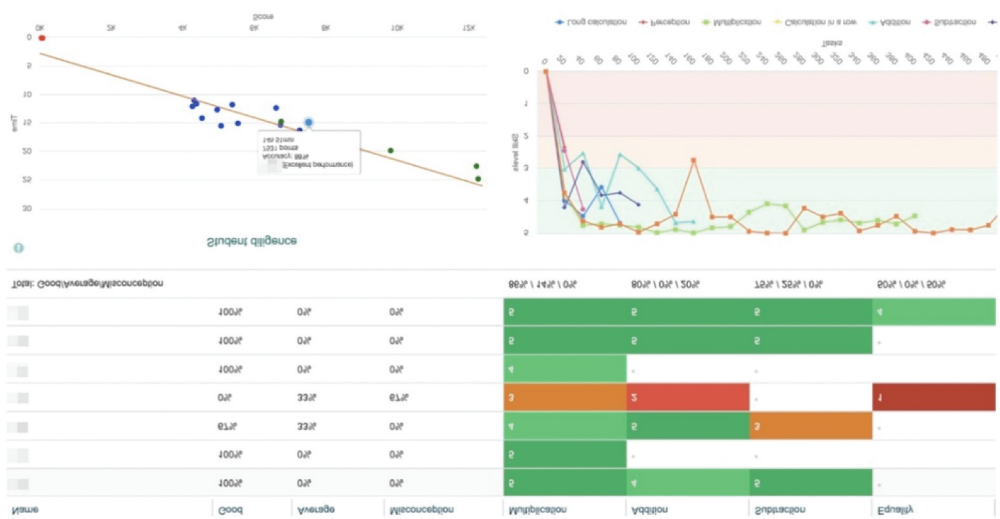


Figure 3. Automated assessment (left frames) and curricula dashboard (right frame).

Figure 4. Teachers' view of the learning analytics dashboard.



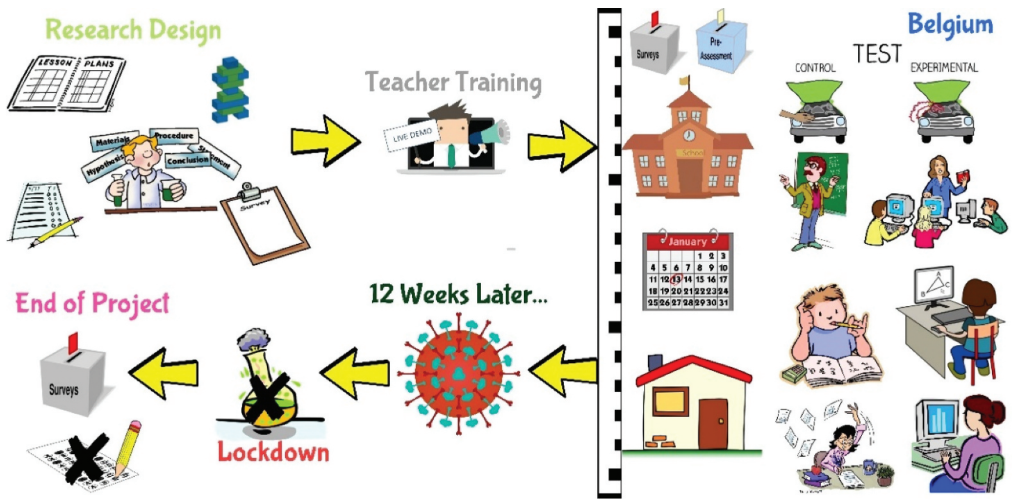
5.2. The digital learning platform

Erümit and Çetin (2020) argue that "to meet the requirements of the information age and the changing needs of the new generations [...] it is important to use new technologies and approaches when designing user-centered learning environments". In line with this claim, the integrated ITS (henceforth referenced as "the platform") provides fully customized digital learning paths—with multiple lessons and exercises—spanning compulsory to tertiary education (Laakso et al., 2018). Each learning path utilizes different instructional elements that align with each learner's curriculum and needs (Figure 2) (Christopoulos et al., 2020).

Moreover, the pilot platform features mechanisms that automate assessment and evaluation processes while also providing immediate feedback (Figure 3, left frames). The customizable dashboard enables educators to create and share curricula content tailored to individual needs or the national curriculum (Figure 3, right frame).

Besides these instructional features, the platform's comprehensive Learning Analytics (LA) offers teachers key information about student performance (individual- or class-level) in real-time. Data

Figure 5. Overview of the research design.



(e.g., preferences, completion rates, response time, score) are displayed to facilitate monitoring of students' progression, and diverse EDM algorithms identify and display learners' misconceptions via the teachers' dashboard (Figure 4).

5.3. Research design

To investigate the proposed research question, the Centre for Learning Analytics, University of Turku, tech team supported participating schools by arranging to accommodate the new teachers and students on the platform, and the pedagogical experts provided training to stakeholders (Figure 5). The topics that were covered included using the environment as a teacher or student, setting up personalized learning paths, leveraging gamification elements, and using the LA features. The research team coordinated the design of the data-collection instruments (knowledge-assessment tests, psychometric instruments) and the customization of the digital learning content to reflect the curricula provided by participating schoolteachers. Local coordinators bridged participants (teachers, students) and the expert team by conducting teacher training sessions and managing operations related to the study.

The study was scheduled for 12 teaching weeks (15 weeks minus national holidays). Prior to the conduct of the study, the representative schools were split randomly in two groups; the control groups continued mathematics classes following standardized methods and tools, and the treatment groups undertook one of their weekly mathematics classes (including homework) as an electronic lesson. The use of the platform for additional practicing was left to teachers' and students' discretion.

5.4. Research methodology

Cohen et al. (2011) recommend the adoption of multiple research methods, when conducting educational research, to promote a wider and more diverse viewpoint of the investigation, increase data accuracy, provide more substantial conclusions, and minimize the limitations of each research method.

Based on these recommendations, the study used a mixed-methods research design that allows the triangulation of primary data. As a result, participants' opinions were recorded through Likert scale-based surveys, and their feedback was obtained via open-ended questions. In addition, unofficial semi-structured interviews were held with participating educators to pinpoint influences on their didactic experience using the proposed digital learning platform.

5.5. Data collection

According to the initial plan, students' competencies in mathematics were examined before the intervention using knowledge-based tests per the national curriculum. Upon completion of the experimental study, another set of tests had been prepared for both student cohorts. However, due to the national lockdown, the post-intervention knowledge assessments were canceled for practical reasons and thus, this topic cannot be explored and/or discussed in the present work.

Psychometric instruments were informed by pertinent literature recommendations (Christensen & Knezek, 2000; Wozney et al., 2006) and adapted to the particular needs of this study. The main themes examined from the educators' perspective included demographics, teaching experience, preferred didactic approach, technology competency and literacy skills, attitudes and beliefs regarding ICT in education, experience with educational ICT tools, educational activity planning and workload management using ICT, and evaluation of the newly adopted tutoring system (Appendix A). Items addressing students' viewpoints were streamlined to demographics, adoption of educational ICT tools, use of ICT in activity planning and study management, and evaluation of the newly adopted tutoring system (Appendix B).

The evaluation of the platform was scheduled to take place at the end of the experiment or, otherwise, school year. The data-collection instruments were translated by independent language professionals using the back-translation method and distributed to the participants using the *REDCap* web application (https://www.project-redcap.org/). General (low-risk) ethical approval was obtained from school principals, as teachers and students were responding anonymously with no possible identification of their identity or school.

5.6. Data analysis

As recommended by Clarke et al. (2019), quantitative data were analyzed alongside qualitative data. Likewise, following the recommendations of Johnson (1997), the first stage of the analysis was conducted by the first author and subsequently revised by the second.

The quantitative responses from teachers and students were coded on a numbered scale and analyzed using the *R* software for statistical computing. For the qualitative data, the *thematic analysis* approach was considered to be the most appropriate method as it offers the freedom and the flexibility to process and interpret such data and thus, develop reliable conclusions and implications (Braun and Clarke, 2012). The themes that emerged from open-ended items were analyzed using *Nvivo12*. Reporting of the findings is guided by the topics identified in the theoretical framework and enhanced by the feedback received from teachers and students.

6. Results

Although the data-collection instruments were not designed for remote teaching conditions, the gathered information provided insights related to participants' views about the integration of ICT in education under different conditions and circumstances. Therefore, when evaluating the perceived usefulness of the platform, adjustments were made to consider the impact caused by the Covid-19 pandemic.

6.1. Educators

6.1.1. Demographics

Eighteen (13 female, 5 male) suburban Belgian state schoolteachers participated in the study, but only 15 provided feedback (11 female, 4 male). Most teachers were mathematicians (secondary education) plus several all-subject instructors (primary education). Sixty percent were young (22–34 years old), and the rest were middle-aged (35–54 years old). Also, 46.6% were at the start of their career (0–5 years in service), 20% were in midcareer (6–14 years), and 33.4% had an established career (15 years or more). Unlike primary education teachers, who led small classes

(10–15 students), secondary education teachers had mid-sized (16–20 students) to large (21–25 students) classes.

Despite varied ages and experiences, no instructor preferred the historic "teacher-directed" didactic approach. Instead, the majority (60%) espoused a balance between conventional instruction and active student participation. Two in five reported either shifting this balance toward the latter or already employing student-driven didactic techniques.

6.1.2. Confidence with using technology

Concerning the integration of ICT at school, nearly half of participating teachers (46.7%) reported using educational technology daily, and a smaller portion (20%) did so a few times (2–4) a week. Two participants mentioned using computers at school less frequently (2–4 times a month), and three had never employed any technological platform for instructional purposes.

Participants' position on the technology integration spectrum varied, as 40% had just started gaining a sense of familiarity while using specific digital learning tools. Those (20%) who had been using educational technology for longer felt comfortable adapting applications to the curriculum to communicate unique learning objectives. However, supporters of educational reform (26.6%) were less concerned about the potential of ICT in this context, as they were already incorporating similar solutions to address their professional needs and facilitate student learning. Lastly, a few teachers reported feeling comfortable with using technology but noted their limited experience with available educational platforms. An agreement across all participating teachers emerged regarding causes of frustration and anxiety (e.g., technical malfunctions) or a lack of self-confidence, especially when exploring new technologies.

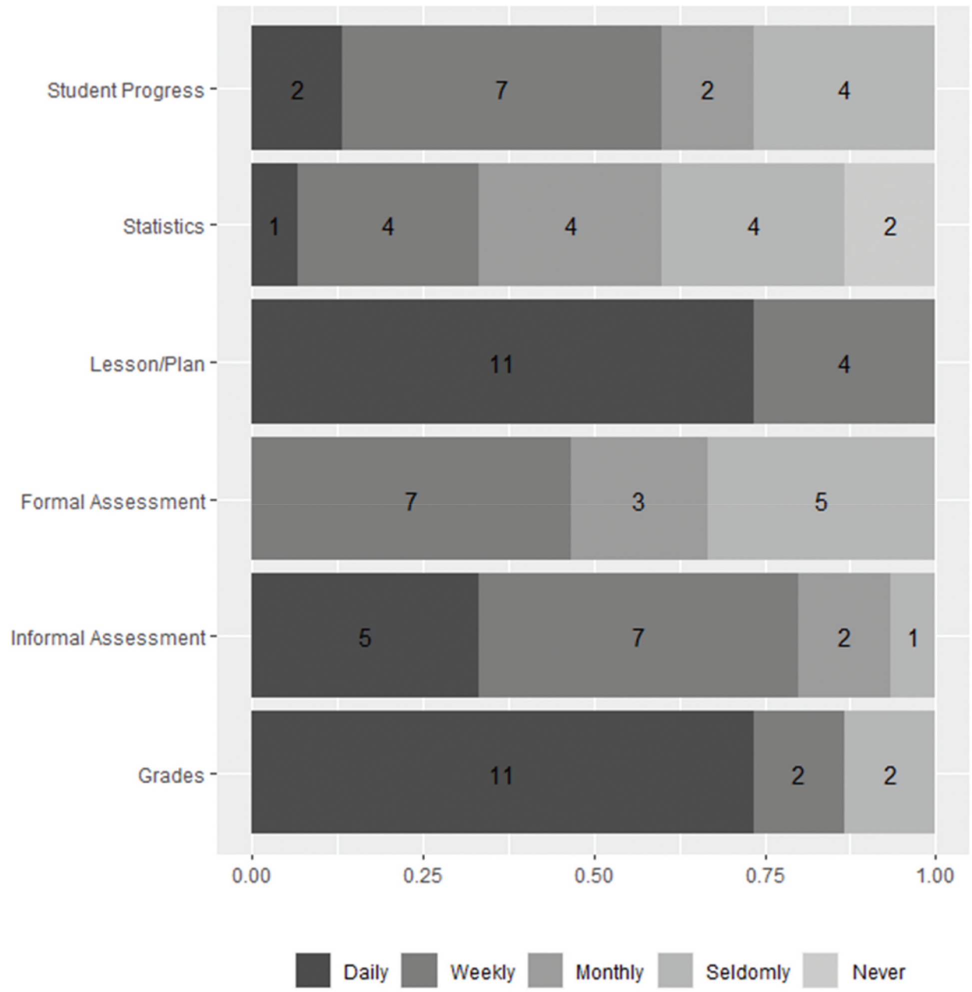
6.1.3. Perspectives on technological usefulness

Educators with prior ICT experience described this exposure as positive (46.7%) and noted its potential to mediate learning. However, those who were less experienced (15.3%) or lacked the

Table 1. ICT tools used for instructional and monitoring purposes by teachers for at least 6 months (n = 12)

(Educational) Tools	Purpose	Subject	Frequency	
			N	Percent
Bingel	Exercises	Mathematics, language	1	8.3%
Digital book widgets	Exercises	Geometry	2	16.6%
Diddit	Exercises	Various	2	16.6%
GeoGebra	Exercises	Mathematics	1	8.3%
Google Classroom	Learning content, statistics	Various	3	25%
Google Forms	Exercises, assessment (tests)	Various	4	33.3%
Kahoot!	Quizzes	Various	4	33.3%
Lifeliqe (Virtual/ Augmented Reality)	Learning Content	Various	1	8.3%
MS Office	Assignments	Various	1	8.3%
Polpo	Exercises	Mathematics	1	8.3%
Schoodle Play	Exercises	Various	1	8.3%
Smartschool	Learning Content, Exercises	Various	1	8.3%
WeZooz Academy	Movies, Assessments (Quiz)	Various	1	8.3%

Figure 6. Use of ICT tools for instruction and monitoring (n = 15).



infrastructure at school to implement TEL activities (38%) considered their overall experience to be satisfactory. The main (educational) tools, subjects, and tasks for which they used ICT (Table 1) were clustered as follows: lesson preparation and content delivery, knowledge evaluation, grade dissemination, and progress monitoring (Figure 6). However, the latter category was noted at a lesser frequency and by only some participants.

6.1.4. Evaluation of the pilot platform

Participants maintained an overall positive stance across different factors (e.g., impact on instruction, adoption by students, impact on learner engagement, potential of LA). This finding was enhanced by feedback from open-ended questions. Respondents with prior experience reported the deployed platform met their expectations in a similar way to the available solutions. Several teachers with no prior experience also provided positive feedback. However, one in three reported dissatisfaction with the platform, and their reasons are explored below.

Regarding the platform's potential for learning, responses varied (xFigure 7). Sixty-seven percent felt that it had some positive impact on their instructional practices which has been primarily attributed to the increased opportunities offered to their students for knowledge construction or additional practicing as well as on the potential of the tool to support individualized teaching where needed. Indicative examples of such feedback are provided below.

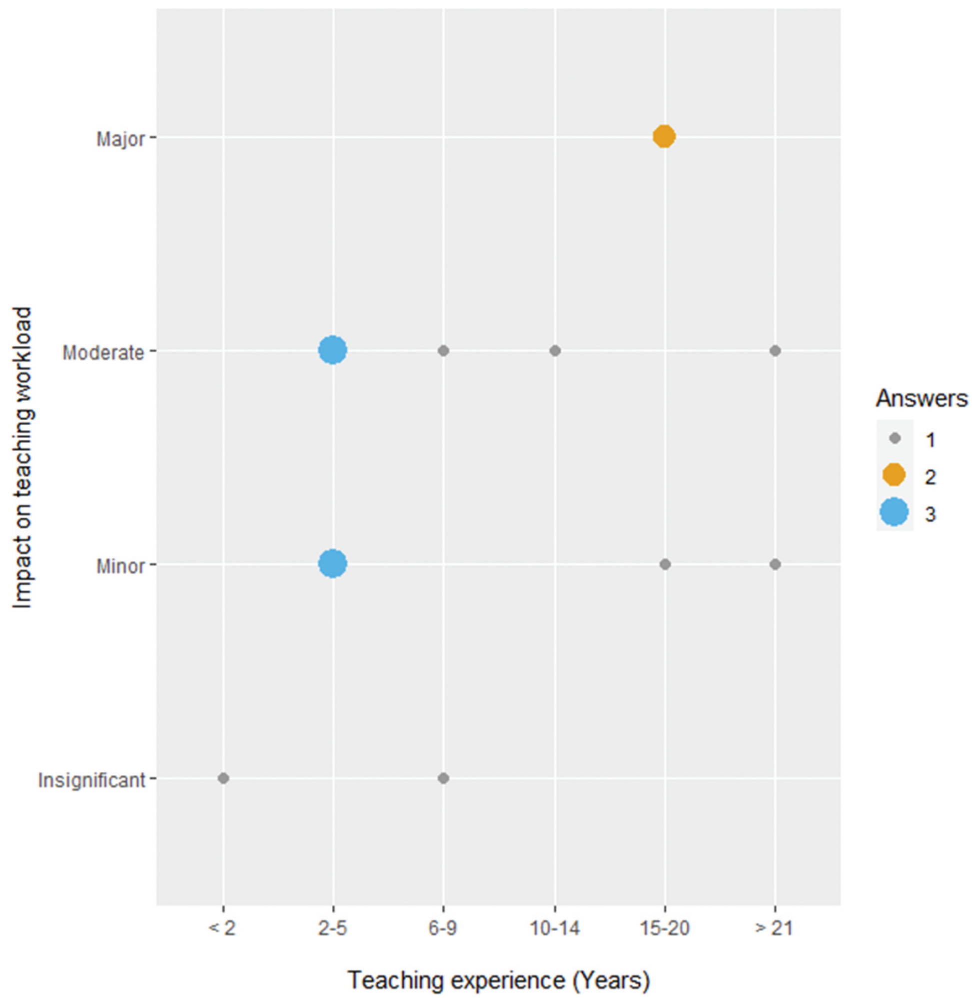


Figure 7. Impact of the platform on instruction correlated with teaching experience (n = 15).

> *"I used it mostly for extra exercises. I don't think using it on a weekly base is needed; instead, I would use it whenever I feel the need for it."*

> *"I had more time for some students to approach them individually."*

However, others observed no significant effect, yet without explicitly justifying the reasons for such outcome.

> *"I did not feel any difference compared to a regular lesson."*

Interestingly, several teachers experienced a major change. For some (27%), the integration of the platform—at least in the school context—positively affected their relationship with students and fostered classroom discourse. Such an outcome was collectively attributed to the enhanced atmosphere that the integration of the platform created in the classroom as it enabled students to play and discuss the educational games. A characteristic quote is as follows:

> *"The students like to be able to do something other than making exercises on paper. It is also nice to talk about and explain the games; they are more motivated this way. There is a nice atmosphere in the group because they can discuss how well they have done something."*

In addition, it motivated learners to practice more frequently yet without realizing the educational impact of such action, as one of the educators reported:

> *"The students liked it. They worked hard at home and also did their best in the other lessons so that we could get extra time to spend with the platform while at school. We went for it together!"*

> *"The students were very motivated to use it. Most of the exercises were clear, although the language made it difficult for them."*

However, several teachers observed no significant difference between the TEL approach and traditional practices, and others even felt disconnected.

> *"There was less interaction between the students and me."*

In the same vein, some teachers stated that they could not fulfil the requirements of their new role as facilitators of the educational process under the aid of the digital learning platform or, otherwise, the alternative didactic approach.

> *"You lose your individuality as a teacher; certain accents that you want to place in the classroom especially in the first and second secondary school."*

Despite efforts to adapt the instructional content from the Finnish to the national (Belgian) curriculum, three in five teachers felt that additional alignment was needed to match students' knowledge background, cognitive skills, and grade-level materials.

> *"The school system in Finland has other 'goals' for maths per year, so as a teacher I had so much more work in finding exercises that fit for us."*

As a result, the rather required additional adjustments to align the provided content to the local context were both demanding in effort and time consuming for the teachers.

> *"The link with the curriculum goals was missing. I had to look for suitable exercises and that took a lot of time."*

Likewise, the lack of translation (e.g., exercise description) into the local language posed a serious barrier and further impacted negatively learners' motivation as several teachers reported.

> *"The children liked the games, but it was difficult that it was in English. I had to keep motivating them to do the exercises."*

> *"The students were motivated to 'play' but English is not their mother tongue and so the exercises were too difficult sometimes."*

> *"It is in English and this was not always easy for our students. The courses should have been translated in Dutch."*

Encouragingly, most teachers (60%) acknowledged the potential of the platform to support students' academic development, despite the issues identified.

> *"The students were more motivated to work with the platform than with the math workbook. The trophy system also helped on that."*

> *"It brings variety to the lessons. Pupils who like to work with computers and do not like to follow lessons felt more attracted."*

In this context, one of the main challenges educators often face involves students' reluctance to engage with the course material or exercises. The deployed platform provided teachers (80%) with the necessary leverage to deal with this issue, with participants noting (40%) the potential of the built-in LA features to facilitate this outcome.

> *"I could monitor the students from my computer, they were making more exercises than in a normal lesson."*

> *"The analytics were very useful. I was able to follow my students' progress."*

Some (33%) felt their students' personal learning preferences and the abovementioned obstacles negatively impacted engagement. In view of this finding, teachers stated that such a tool and such an educational approach would be more appropriate for primary school students, provided it is in their native language.

> *"They were not so enthusiastic: weak students stumbled very much over the English language. Strong students often found the exercises 'boring' because the game aspect in the secondary education is somewhat lost due to the kind of exercises that we have to offer according to the curriculum. I think that in primary school, provided a more user-friendly adjustment to the curriculum and the Dutch language, could be more suitable."*

> *"They liked to work on the computer, but they did not make the transfer to the subjects and lessons that we had seen during the normal lessons."*

6.1.5. Support from learning technologists

More than half of the participants (11) considered the support and guidance provided by the technology and pedagogy experts to be adequate. Those who felt less supported provided recommendations that can improve the training experience in future implementations with regard to the following aspects:

A more elaborate introduction in the beginning to boost teachers' confidence and thus, increase their incentives for more inclusive adoption.

Additional support regarding the elimination of the technical errors as it was not feasible for them to make the necessary adjustments themselves.

More frequent live demos to enable participating teachers better understand the particular features that the tool provides.

Follow up trainings about the potential of the platform to teach other courses.

6.1.6. Impact of Covid-19

In adherence to government orders, schoolteachers suspended new content-delivery activities during the lockdown and instead provided students with revision exercises. Although the platform could cover this need, some teachers (5) who could not accommodate the workload decided to discontinue the platform's use.

> *"Since Corona, we had too much work going on. So, in the beginning I was very motivated to learn about it and use it, but it was too overwhelming to keep it going during the lockdown."*

6.2. Learners

6.2.1. Demographics

In total, 339 students participated in the study, and 335 provided complete responses. The final samples consisted of 30 primary-education students (16 boys, 12 girls, and 2 not specified) and 305 lower-secondary students (150 boys, 154 girls, 1 not specified).

6.2.2. Computers in education

All pupils reported having access to computers in school, and nearly all (98%) had access at home. However, primary students had to visit the computer room at school to perform any computer-supported activities (once a week). Consequently, students across different schools mentioned frequent difficulties when utilizing these devices, as they were generally outdated. In contrast, secondary students had easier access to computers, as reflected by their higher frequency of use (i.e., daily).

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pupils' engagement with ICT in school

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pupils' engagement with ICT in school

Figure 8. Incorporation of ICT for learning and practice (n = 318).

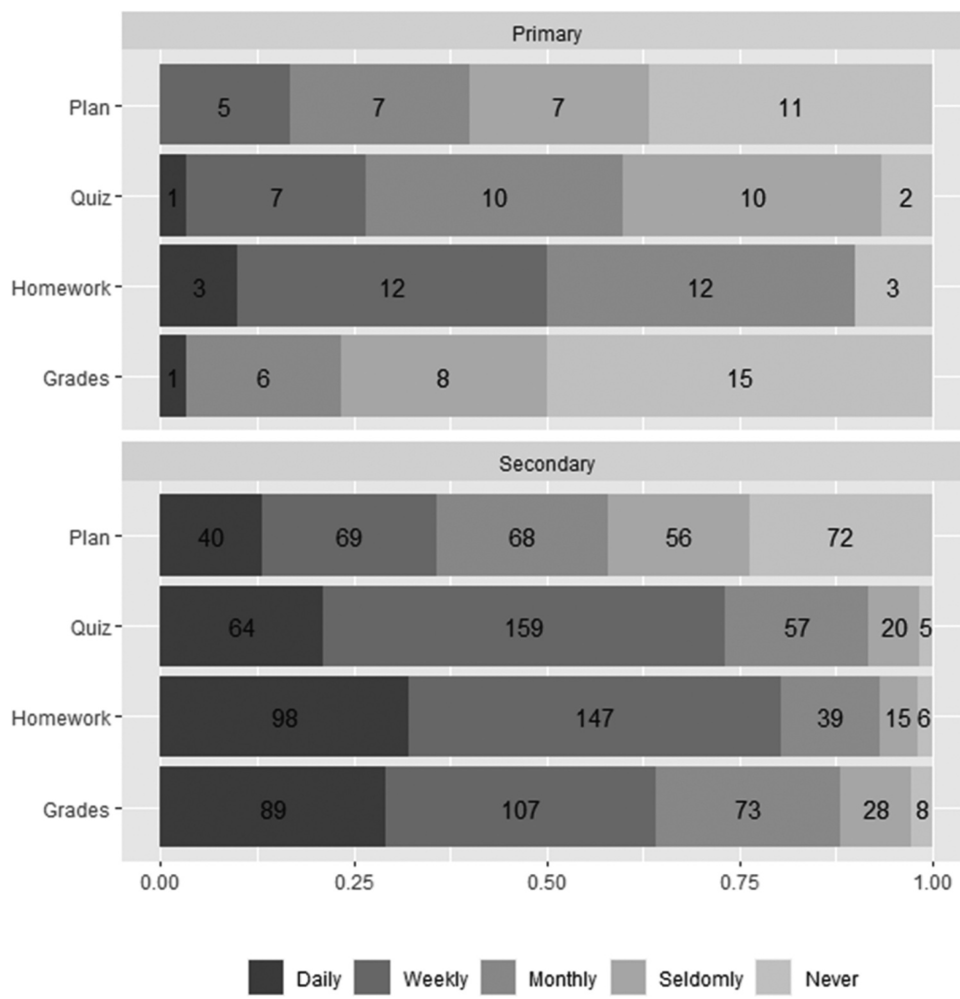

Table 2. ICT tools used for educational purposes by students for at least 6 months (n = 318)

(Educational) Tools	Purpose	Subject	Frequency	
			N	Percent
Pelckmans Portal	Learning content, exercises	Languages, History	39	16%
Duolingo	Exercises	Languages	39	16%
Scoodle Play	Exercises	Various	34	14%
Quizlet	Assessment (informal)	Languages	33	14%
Google Classroom	Learning content	Various	28	12%
Google Forms	Exercises, assessment (formal)	Various	24	10%
Bingel	Exercises	Mathematics, Languages	24	10%
WeZooz Academy	Movies, assessments (quiz)	Natural sciences, geography	19	8%
Diddit	Exercises	Various	19	8%
SmartSchool	Learning content, exercises	Various	15	6%
Tynicards	Exercises	Languages	12	5%
Polpo	Exercises	Mathematics	12	5%
Other (reported <10x)	Learning content, exercises, assessments	Various	20	8%

Table 3. Correlation between experience with the platform and impact on learning (n = 335)

	Impact				
Experience	Insignificant	Minor	Moderate	Substantial	Major
Primary Education					
Very good	1	0	2	0	3
Good	1	3	11	0	2
Acceptable	3	2	0	0	0
Poor	0	0	0	0	0
Very poor	2	0	0	0	0
Secondary Education					
Very good	2	7	36	5	38
Good	18	34	91	2	34
Acceptable	4	11	19	0	0
Poor	3	1	0	0	0
Very poor	0	0	0	0	0

6.2.3. Technology-enhanced learning

The main tasks (Figure 8) that both cohorts had been performing using ICT tools (Table 2) were as follows: progress insight (grades/assessment scores), study plan (scheduling), homework activities (assignments), and assessments (formal and informal).

6.2.4. Evaluation of the pilot platform

Students from both cohorts positively represented their overall experience with the platform, even though its impact on learning was moderate (Table 3).

Primary school students positively interpreted the gamified elements (trophies, reward system, competition dashboard) while noting their impact on knowledge development. As some of them mentioned, engaging in educational games was a pleasant and fun thus, making the school lessons less dull and boring.

> *"The fact that you really got satisfaction with the trophies and also because it is in a playful way, I find it more fun to learn that way."*

> *"That there were games. Because of that it makes you feel like you are gaming instead of doing homework."*

They also noted that the educational games enhanced the retention of the newly acquired knowledge, as they were given the opportunity to repeat the learning exercises whenever they wished.

> *"The fact that you receive the material in a playful way, that helps me to remember things because if I forget an exercise, I link to that exercise and then I remember it."*

> *"You can always make exercises multiple times and there are also games in it and that is also nice for when you have just done a difficult exercise."*

However, based on teacher feedback and some reactions from secondary students, it can be concluded that intense gamification in secondary education would not be perceived as helpful.

> *"Too many games . . . We are no longer in the primary school!"*

> *"Some of the exercises were a bit childish."*

Students' opinions on the context and content of the exercises were mixed. On the positive side, they acknowledged the intuitiveness and creativity of the exercise design, the countless opportunities for practicing, and the alternative instructional approach, especially when compared to the tools and platforms that they had been using.

> *"The creativity of how you get started with the exercises."*

> *"I found the exercises interesting, it is cool to get a diamond/medal."*

> *"The exercises were always great fun and really helped me to master the subject matter."*

On the negative side, they pointed to occasional technical issues (e.g., computer freezing, platform crashing, response time) or the inability of the school infrastructure to support the platform's operational needs.

> *"Sometimes it froze/crashed completely and I had to wait for a long time or even start all over again."*

> *"The platform sometimes crashes on Chromebook and I could hardly use it on the school computers [as an alternative]."*

Lastly, one in three disliked the lack of connection with the school curriculum as, even small differences in the order of the digital exercises with the math workbook caused stress.

> *"Sometimes it is a little different from what we know and that creates confusion."*

Concerning specific exercise elements, a portion of students found them "too simple" whereas others felt they were "too difficult". In the former case, the students also noted that the repetition of similar exercises did not add much to their learning whereas, those who found them very difficult, ended up not solving them at all.

Likewise, some students appreciated the variety, while others felt the exercises were boring or repetitive.

> *"Something different than what we do in a normal lesson."*

> *"Many lessons were about the same subject matter and that became very monotonous."*

As with the teachers, students also raised concerns regarding the English descriptions of some exercises. Some viewed this as an opportunity to practice a foreign language, but others regarded the language constraint as a barrier.

> *"I can't speak English at all but because it was in English I can already speak better!"*

> *"Sometimes the exercise was entirely in English and that was very annoying."*

> *"Sometimes I could not understand a word and there was no one I could ask."*

Finally, the "drill and practice" grounding of the platform impacted students' motivation differently: some appreciated the challenge to keep practicing, whereas others felt frustration and dissatisfaction.

> *"You can try again if you are not satisfied with your point."*

> *"We work with a study planner and have to plan everything ourselves. I am not really good at math and we always had to get at least a bronze medal from our teacher, which meant that I had to do exercises again and again until they were perfect. Because of this I sometimes had problems with my working time."*

7. Discussion

The Covid-19 pandemic affected teachers and students considerably, and the full impact has yet to be recognized. Especially during the first wave, teachers adopted different ICT tools in attempts to support their students. Results from studies of educational measures in this context are becoming available, and the present work contributes to this immediate effort—as well as the broader literature—by highlighting specific challenges faced by educators amidst remote teaching constraints.

Despite the age disparity and instruction experience of participating teachers, a clear effort to align their practices with the modern educational system was identified (e.g., advocating a student-centered didactic approach, integrating educational technology solutions). However, in line with prior literature conclusions (e.g., Fraillon et al., 2013), Belgian teachers often utilize commercial digital learning tools for simple tasks (e.g., dissemination of learning content, evaluation of students' knowledge). This outcome can be attributed partially to their digital competencies —which they were actively trying to improve—but also to a lack of up-to-date computers.

The aforementioned findings are in partial agreement with the conclusions drawn by Dogan et al. (i.e., the theoretical foundations on which the conduct of the current work relied on). In the present study, participating teachers acknowledged the potential of educational technology to enhance traditional practices, as demonstrated by their initial enthusiasm for the platform. The presence of a team of educational technologists boosted their confidence and eliminated the burden often posed by the digital orientation process. Moreover, instructors expressed overall agreement with the specific features of the platform, especially the potential to motivate, engage, and support learners' knowledge advancement in mathematics. Teachers who explored the built-in management and monitoring features also noted their potential to provide an individualized learning approach. However, the extra workload that teachers assumed at the start of the lock-down, plus the limited support available from the educational technologists' team, due to the unexpected increase in requests (attributed to the pandemic outbreak), impacted their willingness to use the platform. Such findings are thus, more in line with the recent studies that investigated how the pandemic outbreak impacted educators' perception toward educational technology across different educational levels and fields (c.f., Portillo et al., 2020; Ślaski et al., 2020).

The analysis of student views on the adoption of digital learning systems reveals that even highly customizable tools may not be appropriate or adequate for widespread (national) adoption. Yet, students from both levels mentioned a variety of digital learning tools which have been used to cover different educational needs across a wide variety of subjects. In view of this rather contradictory finding we can only ask: *What are the features that make the aforementioned tools appealing to students? What are the elements that facilitate the learning process and support students' needs the most?*

Regarding the integrated platform, students acknowledged its potential to provide interactive and engaging learning experiences. Nevertheless, the individual impact of the platform varied, as students interpreted the built-in features differently. In the present study this finding can be interpreted after considering students' age group and thus, educational level. Precisely, primary education students were more inclined to interact with the proposed tool when compared to the more mature secondary level students. Another perspective that this finding can be explained emerges from the study that Al Salman et al. (2021) conducted wherein a significant correlation between students' ICT skills and competencies is identified over the perceived usefulness and the perceived potential of the integrated distance learning tools.

For drawbacks of the tested system, students pointed to gaps between the provided educational content and the local curriculum as well as the English exercise descriptions. Despite the efforts to align the pre-made learning paths to the local curricula, the differences (as major or minor they were) caused dissatisfaction to a portion of students. Likewise, the English language used primarily in the functions of the user interface made it hard for some students to work with the integrated tool. Therefore, future efforts should be conducted with more intense collaboration between the educational technology provider and the local teachers. Likewise, the translation of the user interface should be considered as an essential step to increasing learners' motivation and therefore, satisfaction. Moreover, the high frequency of gamified exercises in lower-secondary education seemed unnecessary. Therefore, as also noted by Hung (2017), particular attention should also be paid when it comes to the degree of gamification or otherwise the frequency that students receive gamified exercises. Lastly, technical malfunctions were highlighted as factors that affected the user experience.

In light of the rapid transformation required of educational systems, this study offers several implications for practice and future research.

- Practitioners who hope to integrate ITS in contexts that differ from the source technology should attend keenly to the deployment protocol. Components would include a project plan with defined steps, fast-paced pilot studies to confirm the tool's appropriateness in that context, extended support from education specialists and technologists before and during the intervention, and fine-tuning of the tool's features based on national and local educational needs.

- The above step should be done in view of the following constructs: awareness of the educational context and the needs of the targeted system, incremental deployment of features, provision of sequential support covering both functional and operational aspects of the deployed system, and integration of the digital learning course(s) based on curricular objectives.
- Instructors and policymakers must understand the implications of changes to the functions and practices of stakeholders, most immediately the post-pandemic strategic planning that will govern the educational ecosystem's evolution.
- Researchers, instructional designers, and educational technologists should seek to measure the dynamics, potential, and adaptability of existing systems to different contexts and user groups.
- Empirical studies related to the adoption of existing digital learning platforms and systems in different learning contexts should focus both on the evaluation of the integration process and the benefits and challenges faced by stakeholders during and after deployment. Data driven practices that underpin the outcomes of these works can help communities prepare for potential crises and reformulate existing strategies.
- Since LA has recently emerged, future efforts should explore in greater detail teachers' and students' perspectives, focusing on key features and information that merits visualization.
- Above all, educational stakeholders should examine carefully the features of potential digital learning tools before broad integration, as this will promote positive outcomes.

8. Research limitations

The obstacles introduced by the pandemic comprise the main limitations of this study. First, the national lockdown and the physical absence of students from the school environment led to the discontinuance of the experimental study, specifically of the intervention's impact on learners' knowledge advancement and academic performance. Second, the increased workload that teachers assumed while remote teaching limited their motivation to explore the platform's features or continue its use.

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Notes

1. In Finland known as '*ViLLE*' and outside Finland as '*Eduten Playground*'

Disclosure Statement
No conflict of interest exists.

Credit Author Statement
A.C.: Conceptualization; Writing - original draft; Writing - review & editing; Methodology; Primary Analysis; Project administration. **P.S.**: Conceptualization; Writing - review & editing; Methodology; Secondary Analysis; Project administration.

Ethics
All procedures followed met the ethical standards of the responsible committee on human experimentation (institutional and national). Informed consent was obtained from all participants for inclusion in the study.

Availability of Data and Material
Anonymized data that support the findings of this study are available from the corresponding author upon request.

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Part 1—Demographics & Teaching Experience

(1) **Please indicate your gender**.

(A) Male

(B) Female

(C) Prefer not to answer

(2) **Please indicate your age group**.

(A) Under 25 years old

(B) 25–34 years old

(C) 35–44 years old

(D) 45–54 years old

(E) Over 55

(3) **Please indicate your teaching experience**.

(A) This is my first year teaching

(B) 2–5 years

(C) 6–9 years

(D) 10–14 years

(E) 15–20 years

(F) Over 21 years

(4) **Please indicate your preferred teaching approach**.

(A) Largely teacher-directed

(B) More teacher-directed than student-centered

(C) Even balance between teacher-directed and student-centered activities

(D) More student-centered than teacher-directed

(E) Largely student-centered

(5) **Please indicate the average size of your class**.

(A) Fewer than 10 students

(B) 10–15 students

(C) 16–20 students

(D) 21–25 students

(E) 26–30 students

(F) More than 30 students

Part 2—ICT Integration in School

(1) **How often do your students use computers at school?**

(A) On a daily basis

(B) On a weekly basis (at least once)

(C) Monthly (2–4 times a month)

(D) Seldom (on special occasions/ only when necessary)

(E) Never

(2) **Please indicate how often you integrate computer technologies in your teaching activities**.

(A) On a daily basis

(B) On a weekly basis (2–4 times)

(C) Monthly (2–4 times a month)

(D) Seldomly (on special occasions/only when necessary)

(E) Never

(3) **Please determine your familiarity with educational technologies**.

(A) Unfamiliar—I have no experience with educational technologies.

(B) Newcomer—I have attempted to use educational technologies, but I still require help on a regular basis.

(C) Beginner—I am able to perform basic functions in a limited number of educational applications.

(D) Average—I demonstrate a general competency in a number of educational applications.

(E) Advanced—I have acquired the ability to competently use a broad spectrum of educational technologies.

(F) Expert—I am extremely proficient in using a wide variety of educational technologies.

(4) **Please read the following descriptions and choose the stage that best describes where you are in the process of integrating computer technology in teaching activities**.

(A) Awareness: I am aware that technology exists, but have not used it—perhaps I'm even avoiding it. I am anxious about the prospect of using computers.

(B) Learning: I am currently trying to learn the basics. I am sometimes frustrated using computers and I lack confidence when using them.

(C) Understanding: I am beginning to understand the process of using technology and can think of specific tasks in which it might be useful.

(D) Familiarity: I am gaining a sense of self-confidence in using the computer for specific tasks. I am starting to feel comfortable using the computer.

(E) Adaptation: I think about the computer as an instructional tool to help me, and I am no longer concerned about it as technology. I can use many different computer applications.

(F) Creative Application: I can apply what I know about technology in the classroom. I am able to use it as an instructional aid and have integrated computers into the curriculum.

(5) **Please indicate how frequently you use computer technologies for each of the activities listed below**.

Part 3—Educational Tools & Teaching Practices

(1) **Please describe your experience as teacher/instructor with educational tools/platforms other than the pilot platform**.

(A) Very Negative

(B) Negative

(C) Acceptable

(D) Positive

(E) Very Positive

(F) I have no other experience.

(2) **[Follow up to 3.1] If you have experience, please indicate which educational tools/platforms you have utilized, for how long, and for which subjects.**

(3) **Please describe your teaching experience with the pilot platform**.

(A) Very Negative

(B) Negative

(C) Acceptable

(D) Positive

(A) Very Positive

(1) **[Follow up to 3.5] Please briefly justify/elaborate on the rationale of your answers as regards the impact of the pilot platform on your teaching duties (A. Relational component—bonding with the students, B. Instructional support, C. Student engagement, D. Classroom organization).**

(2) **Thinking forward, what impact would you expect the newly adopted platform to have on your workload in the future?**

(A) Insignificant impact on workload

(B) Minor impact on workload

(C) Moderate impact on workload

(D) Substantial impact on workload

(E) Major impact on workload

(3) **Please list and describe the advantages (max 3) of using the pilot platform.**

(4) **Please list and describe the disadvantages (max 3) of using the pilot platform.**

(5) **Do you feel skilled enough to work with the pilot platform as a teaching and learning platform? Please justify your answer.**

(6) **Do you feel skilled enough to work with the Learning Analytics dashboard of the pilot platform? Please justify your answer.**

(7) **What kind of training or support would you need to feel fully skilled to work with the pilot platform?**

(8) **Based on your anecdotal observations, please describe how your students perceived the inclusion of the pilot platform to the classroom context.**

(9) **Based on the unofficial feedback or comments that you may have gotten, please describe how parents perceived the inclusion of the pilot platform as a classroom and homework aid.**

Part 1—Demographics

(1) **Please indicate your gender**.

(A) Boy

(B) Girl

(C) Prefer not to answer

(2) **Please indicate your age group**.

(A) 11–12 (primary school)

(B) 12–13 (secondary school)

Part 2—ICT Integration in School

(1) **How often do you use a computer at school for learning activities?**

(A) On a daily basis

(B) On a weekly basis (2–4 times a week)

(C) On a monthly basis (2–4 times a month)

(D) Seldomly (on special occasions/only when necessary)

(E) Never

(2) **How often do you use a computer at home for learning activities?**

(A) On a daily basis

(B) On a weekly basis (2–4 times a week)

(C) On a monthly basis (2–4 times a month)

(D) Seldomly (on special occasions/only when necessary)

(E) Never

(3) **How frequently do you use a computer for each of the activities listed below?**

Part 3—Educational Tools & Teaching Practices

(1) **Please rate your experience with other educational tools/platforms**.

(A) Very Poor

(B) Poor

(C) Acceptable

(D) Good

(E) Very Good

(F) I have no other experience.

(2) **[Follow up to 3.1] If you have experience, please indicate which educational tools/platforms you have utilized, for how long, and for which subjects.**

(3) **Please describe your learning experience with the pilot platform**.

(A) Very Poor

(B) Poor

(C) Acceptable

(D) Good

(E) Very Good

(4) **Please describe how the pilot platform has impacted your learning**.

(A) Insignificant impact on learning

(B) Minor impact on learning

(C) Moderate impact on learning

(D) Major impact on learning

(E) Substantial impact on learning

(5) **What did you like the most when using the pilot platform?**

(6) **What did you like the least when using the pilot platform?**