Time to Face the Truth: Do Digital Applications Really Help Students Learn?

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Abstract: This study explores how first-year Electronics students interact with digital learning resources. The information collected pertains to recorded lectures from the first year of the health crisis in 2020, short videos created at students' request in 2021, a test/video/test (T/V/T) application developed in 2021, and the Multiple-Choice Help (M-CH) application, which was created in 2024. The findings indicate that students' use of digital learning resources is often disconnected from the creators' intentions. Instead of being used systematically, these resources are typically accessed opportunistically, primarily during exam preparation. Factors such as background knowledge and study persistence significantly influence how students utilise these resources. For more complex applications, like the T/V/T and M-CH, students tend to select only those components that align with their immediate needs. High-performing students are generally more inclined to take advantage of digital learning resources, whereas low-performing students and those who do not attend lectures are less engaged. The digital resources employed proved insufficient to reconnect students with learning. Interestingly, satisfaction with a digital resource does not imply its usage or increased academic performance. While the usefulness of digital resources cannot be denied, they play only an assistive role in students' learning.

1 INTRODUCTION

Information and Communication Technologies (ICT) are related to education in two interconnected ways: The first is the total transformation of education and its transfer from the classrooms to the internet, and the second is the cultivation of student personalities that will fit the remote learning environment, and this is the engaged student. For both objectives, technology is the purgatory of political choices and the vehicle for education privatisation.

International organisations treated the COVID-19 hygienic crisis as an opportunity to convince society of the inevitable total transformation of education. UNESCO, the UN, and UNICEF were the active agents to depoliticise the transformation agenda (Facer & Selwyn, 2021; Sharma & Hudson, 2022). Taking advantage of their humanistic image, they became the ideal advocators of the irreversibility of online learning after the end of the pandemic.

Soon, it was found that students were disappointed with online learning and, more importantly, learning was marginal. A survey conducted by the European Students' Union in April 2020 provided reliable evidence of students' preference for in-person education (OECD, 2021). An early World Bank publication concluded that school closures resulted in significant learning losses despite teachers' online efforts (Donnelly et al., 2021). More recent research has provided ample evidence of the learning losses that occurred during forced online learning, undermining the sustainability of the digital transformation proposal (Alasino et al., 2024; Arenas & Gortazar, 2024; Durongkaveroj, 2023; Reich, 2020).

Digital learning resources are considered to promote discovery and create a new type of person: the engaged student (Ahshan, 2021). Evidence in favour of the positive impact of technology on learning comes from studies conducted in specific

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contexts and as part of planned research projects. However, such results are not susceptible to generalisations. Evidence from real classrooms has failed to establish a robust relationship between technology and learning, while studies on technology integration in real classrooms have yielded mixed results. Moreover, the novelty effect, poses additional problems in establishing a clear relationship between education technology and learning (Fütterer et al., 2022).

To address the lack of supporting evidence and maintain a positive relationship between technology and engagement, some researchers suggest that previous studies have mistakenly searched for a link between cognitive engagement and the frequency of technology use. As a result, recent research has shifted attention to the relationship between cognitive engagement and the quality of technology integration (Cattaneo et al., 2025; Chi et al., 2018; Fütterer et al., 2022; Trask, 2024). The emphasis on the "quality of integration" rejuvenates the discussion of the relationship between technology and cognitive engagement, overcoming the lack of evidence on the cognitive engagement–technology relationship.

Digital education is as challenging to generate results as analogue education. This study focuses on the evidence on how students interact with digital learning tools designed to enhance their learning. The idiosyncratic and sometimes opportunistic ways students interact with digital learning tools question the extent to which they can play the role their creators consider they would play (Pitso, 2023). It is not the deployment of digital learning tools per se that generates results but the extent to which learning resources are incorporated into a carefully designed process that makes students put effort into their learning (Alahmadi, 2023; Biehler et al., 2024; Gao et al., 2024).

The pro-technology rhetoric and the forced familiarisation of tutors with digital learning tools cultivated the belief that technology can cure the weaknesses of classroom teaching. Teachers must correctly identify students' educational needs and develop or utilise appropriate digital resources (Kostaki & Linardakis, 2024). Teachers develop applications in tandem with high expectations regarding their impact on student learning. However, what digital learning resources mean to students remains an open question. This study highlights how students interacted with digital learning tools between 2020 and 2024. The research questions are the following:

How did the students use the digital learning tools?

What impact did the digital learning tools have on students' learning?

Did the digital learning tools benefit all students equally?

2 DATA AND SOURCES

The collected data covers the period from 2020 to 2024 and focuses on first-year Electrical and Electronic Engineering courses. Information on video viewing was extracted from YouTube analytics. In 2021, a questionnaire distributed to 72 students captured feedback on the T/V/T application. Finally, information regarding the usage of the M-CH application was obtained from the application's database, and a survey gathered additional student feedback.

3 RESULTS AND DISCUSIONS

The following sections describe students' interaction with a) the video lectures during 2020, the first year of the movement restrictions due to the COVID pandemic, b) A set of 24 short videos made available to the students in 2024, c) An application combining a pre-test, a video and a post-test made available in March 2021, d) The custom web application "Multiple-Choice Help" consisting of multiple-choice tests with a "Help" button.

3.1 Recorded Video Lectures

During the pandemic, video lectures were considered a better solution compared to synchronous lectures. They made any-time, any-place learning a reality aligning with OECD recommendations for 'grassroots solutions' (p. 67), development of material accessible "at any time" (p. 121), learning tools of "quick and easy scalability (p.134) ", multimodal pedagogical resources" (p.165), and "recordings of daily video lessons" (p.236) (OECD, 2022).

The video lectures discussed in this section refer to remote teaching between March and June 2020. On the basis of data collected from YouTube, Figure 1 shows the variation in watching time and number of viewers over a period of 13 weeks.

The first two weeks were the exploration period when the number of visitors increased but the total viewing time decreased. The students accessed the video lectures to decide whether they suited their

learning and personal needs. After the second week, the number of viewers and total viewing time decreased in tandem until the Easter holidays. Viewing time increased before phase and final exams, during the 9th and the 13th week, while the number of viewers remained low. This suggests that a small group of students engaged with the videos for longer durations (Dermy et al., 2022).

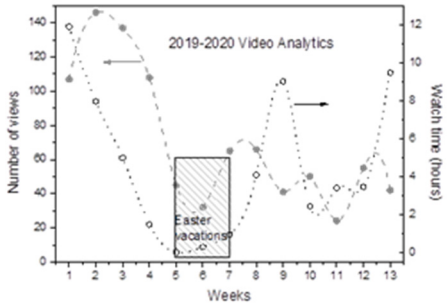

Figure 1: The viewers decrease 50% in 8 weeks. The watching hours varied depending on students' duties (phase exams).

It was expected that posting recorded video lectures on a virtual platform would enable the students to download and watch them offline, allowing them to review the learning material. Still, recorded video lectures are often considered ineffective teaching material because they can be lengthy and do not promote the dialogue between students and teachers. They attracted students' attention only at the beginning of a course and before the exams (Cavanlit et al., 2023; Karnad, 2013). Although they were considered to facilitate flexible learning, only a small number of students benefited from them.

3.2 Targeted Video Material

Short-length videos are more effective than video lectures because they prevent viewers' passivity and reduce mind-wandering. Segmenting a long text into small videos reduces the cognitive load during viewing and improves the structuring of the learning material (Seidel, 2024). This section discusses how students interacted with 24 short videos, each lasting approximately 10 minutes, uploaded on the LMS in July 2024. The videos covered management and technology, covering half of the learning material for two first-year electives: "Management" and "Science, Technology, and Society."

A calculation combining viewing times, average video duration, and the number of views per video, yielded that, on average, the viewers watched 41% of the average video length, translating to about 3.5 minutes. Some videos garnered significantly more attention, with viewers watching, on average, 66% of their duration, while others received less attention, with viewers only watching about 13%. As illustrated in Figure 2, the students engaged with the videos a few days before the July and September exams as an alternative to reviewing course notes

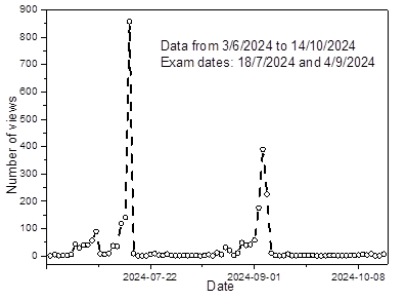

Figure 2: The students interacted with the videos opportunistically only a few days before the July and September exams.

Figure 3 depicts student engagement with videos in July 2024. Following the videos' release on July 7, 2024, a small number of viewers watched the videos, with an average viewing time of approximately 5 minutes, accounting for about 60% of the average video duration. Over the following 12 days, viewing times fluctuated, showing local peaks on July 7, 12, and 17. The number of views remained low until July 17—the day before the examination—when views surged to approximately 850, with an average viewing time of 4 minutes per video. Students used the videos reactively, not as a core resource, resulting in viewing spikes before exams. Engagement with the videos was not continuous and did not result in a continuous rate of knowledge acquisition. However, digital learning tools, including videos, can lead to robust learning when they are integrated in carefully designed learning events (Fütterer et al., 2022; Koedinger et al., 2012).

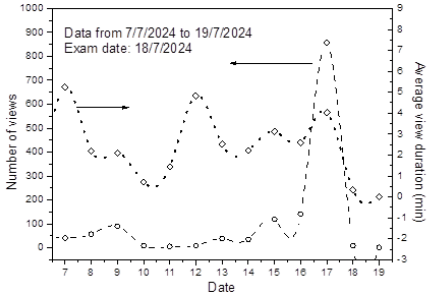

Figure 3: The students engaged with the videos only the day before the exams.

3.3 The "M-C Test/Video/M-C Test" (T/V/T) Application

Students learn from videos when they take control of their learning process. Instructional strategies prompting the students to complete tasks alongside watching videos help them take control of their learning. In a T/V/T exercise, a video was paired with an objective test to enhance students' active engagement with video learning (Tan et al., 2022). Other publications use self-explanations instead of objective tests (Bai et al., 2022; Lawson & Mayer, 2021; Wang & Xu, 2024). A T/V/T exercise proceeded as follows: First, students took a problem-based multiple-choice test to self-assess their knowledge of a specific topic and identify potential areas of confusion (Photopoulos et al., 2021; Photopoulos & Triantis, 2022). Students scoring below 6.5 out of 10 were prompted to watch an online video to clarify misunderstandings. After viewing the video, they were further prompted to retake the test to demonstrate improvement. Students who scored above 7/10 did not have to proceed to the above steps but were welcome to do so if they chose.

In the spring of 2021, approximately 90 students participated in synchronous remote lectures in Electronics. Attendance remained high throughout the semester. The learning resources included text files with solved and unsolved problems for each teaching unit. Additionally, two Test/Video/Test (T/V/T) exercises were uploaded to the Learning Management System (LMS) for home study on April 4, 2021. These exercises were designed to help low-performing students identify areas of confusion and improve on them.

A questionnaire was distributed to the students to gather feedback on the ways students interacted with the T/V/T exercises. A total of 72 students responded. Regarding their year of study, 51% were first-year students, 25% were sophomores, and the remaining students were from other years of study. Among the participants, 89% were male, and 92% reported attending lectures regularly. However, only 12 students (approximately 17%) reported studying the exercises uploaded to the LMS.

3.3.1 The First T/V/T Exercise

Of 72 survey participants, 15 did not report their first test grade and were excluded from the analysis. Among the remaining 57 students, 26 scored lower than 6.5/10 on the first test. Although these students were directed to the video, only 10 reported watching it (38%), and even fewer (31%) completed the third application step, i.e. to retake the test. Of the eight students who scored below 5/10 on the first test, only 3 watched the video, and just 2 (25%) took the multiple-choice retest.

In contrast, 12 out of 31 students who scored 7 out of 10 or higher on the first test watched the video and retook the test, accounting for 39% even though the application did not explicitly require this step. These results indicate that high-performing students benefited the most from the T/V/T application, while students who performed poorly on the first test showed less interest in completing the rest of the application. Ultimately, the T/V/T application did not equally benefit all students.

The students used the app idiosyncratically. Five students took the two tests without watching the video. Another four students took the first test and watched the video but did not attempt the retest. Among the 25 students who did not watch the videos, 11 cited having no time, and 12 that their first test mark was above 7/10.

Despite these usage patterns, of the 20 text responses on the video's effectiveness in enhancing learning, only one student expressed dissatisfaction about the video's length. In contrast, 11 participants made positive remarks about the video, and eight explained the reasons for not watching it, e.g., "I will watch it during the weekend." Overall, the participants rated the video's effectiveness in facilitating learning with an average score of 4.2 on a scale of 1 to 5.

3.3.2 The Second T/V/T Exercise

Out of the 72 students surveyed, 15 did not report their first test grade and were excluded from the analysis. Approximately 17% of the respondents fully utilised the application, completing both tests and watching the video regardless of the first test performance.

Among the six (6) students who scored less than 5/10, only one student (16.7%) reported that they watched the video carefully and took the retest. Two additional students took the retest without watching the video, and one student skimmed through the video before taking the retest.

Of the 12 students who scored between 5 and 6.5 out of 10, only two (16.7%) watched the video carefully and took the multiple-choice retest. One student skimmed through the video before retaking the test, and another student only took the retest without viewing the video.

Among the 39 students who scored above 7/10, eleven self-reported watching the video carefully

(28%), and seven of them went on to complete the multiple-choice retest (18%). Five students took the retest without watching the video, and three skimmed through it without taking the retest.

Fourteen students provided written feedback on the effectiveness of the video in enhancing their learning, and no negative comments were received. On a scale from 1 to 5, participants rated the video's contribution to their learning, with an average score of 4.2.

The overall results indicate that, on average, 50% of the students engaged with the exercise components selectively. Students practised autonomous learning, choosing which parts of the application suited their perceived needs (Tan et al., 2022). Among low-performing students, the percentage who treated the app as a cohesive learning resource and completed all three steps decreased from 25% in the first exercise to 17% in the second. These findings suggest that regardless of the designers' intentions and students' evaluations, the digital application did not effectively benefit all students as intended (Fiorella, 2022).

Cognitive load theory is a candidate for explaining how students' performance affects cognitive engagement with digital applications. Cognitive load significantly influences the effectiveness of integrated learning strategies that involve multimedia. Decoding, assimilating, and accommodating alternative representations and understanding their relation to physical quantities demand a high cognitive effort (Lawson & Mayer, 2021). Multiple-answer problem-based questions demand extensive pen-and-paper calculations to make an informed choice (Photopoulos & Triantis, 2022). High performers have learned to manage high cognitive loads and accept the challenge of completing the applications, while low performers may struggle. When learning is left to the discretion of the unaided learner, it is often unclear whether the cognitive load will foster engagement or hinder learning. Research indicates that excessive cognitive load negatively impacts knowledge transfer (Bai et al., 2022), while reduced cognitive load may result in insufficient cognitive engagement (Wang & Xu, 2024). Finding an 'optimum' cognitive load that works well for all students is as challenging as offering personalised learning in the class environment.

Combining multiple-choice tests with video lectures is seemingly an effective strategy for engaging students with video content and providing immediate feedback on their learning (Divjak et al., 2024; Jarwopuspito et al., 2023; Tolonen et al., 2023). However, some students do not benefit either from videos or traditional classroom teaching (TS & Thandeeswaran, 2024).

3.4 The "Multiple-Choice Help" (M-Ch) Application

Multiple-choice help (M-CH) is a custom web application developed using PHP, with data managed through a MariaDB database. Its architecture followed a sequential series of Multiple-Choice questions with a help text. The application recorded various data, such as the correct answers, the time spent on each item, and the time remaining on the help screen. Users accessed the application through a web browser. An Android mobile application was also experimentally created, utilising the Apache Cordova development environment. The tests were on topics from two first-year electives: "Management" and "Science, Technology, and Society" (Table I). "An App for Everyone, Especially for Students Not Attending Lectures", said the announcement, making the application available on February 11, 2024. Three months later, a single-digit number of students had visited the app.

Table 1: Multiple-Choice Help Statistics.

	Number of students	Average correct answers per student	Average time per item (sec)	Percentage of correct answers (%)
Technology and Employment	66	13,0	40	46
Technology Acceptance Model	29	11,5	49	55
Performance and Evaluation	31	12,0	62	60

A July 7, 2024, announcement, 11 days before the exams, reminded students of the application. The application aimed to scaffold students' learning using the multiple-choice format. Table I presents the information collected. Of the 140 students who took the July 2024 exam, less than 50% visited the app. The average time spent per item was about one minute, indicating that students went through the questions rather than paying attention to the 'help texts'. The evidence indicates that the students used the application to understand what exam questions to expect rather than as a learning resource. Additionally, the pass rate for students who used the application was not significantly higher than the overall pass rate, suggesting that the application did not significantly impact student performance.

The preliminary results of a survey among application users indicate a positive attitude. Eighty-

five percent reported that the questions and "help texts" were clear and understandable, and a similar percentage said that the application helped them learn. Ninety percent reported satisfaction with the application, and 93% would recommend it to another colleague.

4 CONCLUSIONS

How did the students use the digital learning tools? The participants of this study used the digital learning tools reactively, often focusing on responding to the forthcoming assessment rather than engaging with the content. The same pattern appeared in the case of the short-targeted videos published in 2024. During remote teaching in 2020, interest in video lectures dropped by 50% within four weeks, with sporadic viewing spikes appearing before exams. Students used the components of the T/V/T components selectively; some emphasised the multiple-choice tests, others the videos. Only a small percentage of low-performing students completed the applications, with 25% finishing the first exercise and 17% completing the second. Additionally, only 50% of the students who took the July 2024 exams used the M-CH application. On average, students spent about one minute on each M-C item, indicating limited use of the 'help text.' Overall, the digital learning tools served as supplemental aids rather than the primary learning resources with usage patterns that were opportunistic and superficial. These behaviours reflect reactive, exam-driven usage rather than consistent, deep learning-focused (Boud & Molloy, 2013).

What impact did the digital learning tools have on students' learning? The tools had little impact on students' learning and maintained or reinforced existing performance disparities rather than closing gaps. Engagement patterns were determined by exam-driven urgency and disparities in performance rather than consistent, deep learning (Boud & Molloy, 2013). Low performers rarely took advantage of applications' remediation features, such as video viewing and retests, resulting in minimal improvement in learning. In the case of the M-CH application, there was no significant improvement in pass rates compared to non-users. Peaks in video viewing before exams suggest surface-level cramming rather than deep learning (Bjork et al., 2013). Although the students were satisfied with the applications, the learning tools did not ensure learning gains for all.

Did the digital learning tools benefit all students equally? The present study suggests that low-performing and non-conventional students received fewer benefits than high-performing students. Evidence from the T/V/T application suggests that it was more beneficial for high-performing students. The M-CH application did not attract the attention of the students who did not follow the lectures, contradicting assertions about flexible digital learning. Students often used tools idiosyncratically, skipping videos or superficially interacting with applications. The outcomes of the present study align with publications showing that self-directed learning tools, not paired with accountability mechanisms, often widen achievement gaps (Koedinger et al., 2012).

Several studies report positive outcomes from introducing digital applications in higher education (Tomić & Radovanović, 2024). Although some students may improve in performance or feel satisfied with digital learning tools, they do not ensure effective learning for all (Santilli et al., 2025). Moreover, the novelty effect further obscures safe conclusions. In designed experiments, the use of an application follows the research design. However, in real life, students have the option to approach digital tools idiosyncratically or opportunistically, contrary to the designer's intentions (Fütterer et al., 2022; Tomberg et al., 2024).

This study suggests that, for the specific community of learners, digital instructional resources do not promote meaningful learning when left solely to the student's discretion. Apart from a portion of students engaged with learning, the rest use the instructional resources superficially and reactively to meet examination requirements. For instructional material to be effective, students must take ownership of their learning process. Integrating the learning tools in a carefully designed learning process orchestrated by the instructor and implemented by the students and the teacher can help achieve this objective (Gao et al., 2024).

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