

2023-10-10

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Recommended Citation

Kooli-Chaabane, H., Lanthony, A., & Peyret, N. (2023). Learning Through Screens During COVID-19 Crisis: Foresee Tomorrow's Education By Analyzing Yesterday's Setbacks And Barriers. European Society for Engineering Education (SEFI). DOI: 10.21427/QTJX-AJ72

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LEARNING THROUGH SCREENS DURING COVID-19 CRISIS: FORESEE TOMORROW'S EDUCATION BY ANALYZING YESTERDAY'S SETBACKS AND BARRIERS

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Conference Key Areas: *Tracks 10: Virtual and Remote education in a post-Covid world; Tracks 11: Innovative Teaching and Learning Methods*

Keywords: *Learning, Digital Transformation, COVID-19, Problem-Based Learning*

ABSTRACT

This paper aims to enrich the state of the art on engineering and management learning and education by shedding light on the barriers encountered during the COVID-19 crisis due to the imposed digital transformation. Our research question is: what were the barriers encountered in remote and hybrid learning during pandemic experiences and what lessons can be drawn for higher education in the context of Problem-Based Learning (PBL)? This paper aims to enrich the debate on how digitalization impacted the learning and teaching experience in teaching modules traditionally achieved face-to-face.

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To investigate our research question, we adopted an abductive, quantitative, and qualitative approach through a case study methodology. Based on our literature review we proposed a five-fold barriers taxonomy: (a) technical, (b) anthropologic, (c) epistemic, (d) didactic, and (e) financial barriers faced during the technology-intensive learning experience. These barriers have been audited in the context of a French engineering school. The analysis of the barriers confirmed by the field study made it possible to highlight three must-do actions: (A) develop the ability to learn, (B) develop agility, and (C) empower teachers and students. These actions aim to ensure better quality and resilience of the future learning process in the post-covid world.

1 INTRODUCTION

Well before the COVID-19 crisis, people were immersed in a digital lifestyle where IT is embedded in everyday activities (Devaux et al. 2017). In the United States of America, over half of the children (53%) own a smartphone by the age of 11, and 84 % of teenagers have their own smartphones (Rideout and Robb 2019). In France, 38% of people admit that they sometimes consult their screen during family meals (ELABE 2019). Digital transformation plans were already on the agenda before the pandemic situation. The economic and health impacts of the pandemic crisis have made them a top priority (Vollmer 2020). According to a study carried out by McKinsey & Company (LaBerge et. al. 2020), COVID-19 has accelerated the adoption of digital technologies by several years. The modern world has turned to digitalization and digital tools to cope with lockdowns and to reinvent an environment of collaboration (Liu and Shirley 2021). Since then, in some ways, screens have become inescapable.

The measures adopted due to the pandemic crisis have profoundly challenged the learning and teaching processes (Almarzooq et. al. 2020). The implementation of pedagogical approaches where formal and informal exchanges are very important to drive deep learning has been undermined (Greenberg and Hibbert 2020). Some curricula have been challenged more than others due to the experimental (Greenberg and Hibbert 2020) and the technical dimension of targeted competencies fulfilled traditionally by face-to-face learning and learning by doing, generally done in classrooms. It was typically the case for pedagogical approaches such as Problem-Based Learning (PBL). In this approach, the learning process occurs through prepared situations or real situations where the students are highly engaged (Prince and Felder 2006).

The intensive digital transformation of the learning experience due to remote and blended learning has raised many questions. This paper aims to enrich the state of the art in engineering and management learning and education by shedding light on the barriers encountered during the COVID-19 crisis due to the imposed digital transformation. Our research question is: what were the barriers encountered in remote and hybrid learning during pandemic experiences and what lessons can be drawn for higher education in the context of Problem-Based Learning (PBL)?

This study has a threefold objective. The first fold is to identify, understand, and structure the barriers to learning created by the COVID-19 crisis. The second fold is to enrich the empirical knowledge on the subject by providing elements of feedback based on the case study of a French engineering school. The third fold is to propose, on the basis of this feedback, recommendations to practitioners and decision-makers to ensure better quality and resilience of the future learning process.

Our paper is organized as follows. Section 2 provides insights into barriers to Learning in a digital context imposed by COVID-19 through a literature review and proposes a five-fold barriers taxonomy. Section 3 presents the methodology adopted in order to collect, analyze and propose feedback in the context of the studied case study. Section 4 exposes the results of the audit and contextualization of the identified barriers and the proposed must-do actions.

2 BARRIERS TO LEARNING IN A DIGITAL CONTEXT IMPOSED BY COVID-19

A huge amount of research has already focused on the barriers to learning generated by the forced digitalization imposed by the pandemic situation. Using these studies, we proposed a five-category taxonomy: ((a) technical, (b) anthropologic, (c) epistemic, (d) didactic, and (e) financial) for the barriers to learning found in our literature review (see Fig. 1). These barriers can be influenced by other phenomena imposed by the pandemic such as lockdowns, and social distancing.

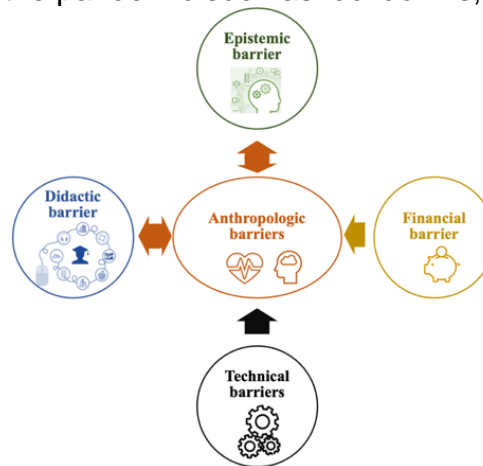


Fig. 1. Proposed taxonomy for the learning barriers in a digital COVID-19 imposed context

2.1 Technical barriers: Internet and software access

Technical problems related to handling platforms and internet connectivity appeared as one of the main sources of stress during exams in COVID-19 periods (Elsalem et. al. 2020) and more generally in the learning experience during the pandemic situation (Vielma and Brey 2021 ; Mohapatra 2020 ; Lanthony et. al. 2021). The poor internet access can make it difficult for teachers and students to access software, share video, or even browse data. It can be a huge problem for them when working remotely, resulting in difficulties to contribute to teamwork. The shift from a well-equipped environment to working from home provoked a feeling of frustration, mainly because of the abruptness of the transition (Thornton 2021). Indeed, while working at home is a “new normal” brought by COVID-19, technical issues can jeopardize the learning experience and turn it into a nightmare. Financial issues can worsen the effect of the technical barrier due to a lack of funds to acquire the required equipment.

2.2 Anthropologic barriers: Well-being, psychological and physical conditions

COVID-19 triggered an exceptional response that affected society's foundation to inhibit contagion (Brammer et. al. 2020). The transformation imposed by the

pandemic situation has impacted individual and population mental health (Galea et. al. 2020). It has put great pressure on the academic ecosystem (Brammer and Clark 2020), especially on students. “Levels of stress, anxiety, loneliness, and depressive symptoms among students have increased since the coronavirus crisis” (Zerhouni et. al. 2021). This pressure has undermined the well-being of stakeholders in the learning process not only because of the abruptness of the transformation but also because of the exceptional workload generated for teachers and learners. The latter had to cope with the challenges of academic learning in tandem with family obligations, financial burdens, and increasing workload due to the pandemic situation (Mohapatra 2020 ; Asgari et. al. 2021 ; Saw et. al. 2020 ; Kooli-Chaabane et. al. 2021). Vielma and Brey (Vielma and Brey 2021) highlight that students have experienced a reduction in their motivation and focus to fulfil their classwork. The question of privacy has been raised by public opinion (Hunter 2021 ; Jenkins 2020). When working or learning time is done on private territory, private aspects can be exposed in front of colleagues or schoolmates. Constant task switching between work and private activities can be mentally tiring (Kossek 2020). This oscillation can make it hard to concentrate on work. This confusion has been the source of discomfort.

Moreover, technology-intensive learning can cause dehumanization of the learning process. The mental health of students came into the public debate in France some months after the beginning of the pandemic. It led the minister for higher education to recommend a full face-to-face 2021-2022 academic year. Official bodies like the French Consultative Commission for Human Rights (FCCHR) pointed out in a report in 2021 “the urgent need to strengthen health services, in particular mental health, within higher education institutions”. In the same report, the FCCHR highlights the risk of a dehumanized learning (CNCDH 2021), focusing on the lack of facial contact, with the camera frequently turned off for technical or personal reasons. It should be noted that most of the students and almost all teachers still in the higher education system in 2023 suffered from these difficult conditions and still have to cope with them during the process of building the post-covid education world.

2.3 Epistemic barrier: The lack of digital skills

During the COVID-19 outbreak, both teachers and students struggled with adapting to remote learning due to the lack of digital skills (Saw et. al. 2020). Indeed, the lack of digital skills can prevent from accessing and being part of digital education (Grand-Clement et. al. 2017). Teachers currently identify the use of digital technologies as one of the areas where they are in greatest need of professional development (Devaux et. al. 2017 ; Mohapatra 2020). The ability to learn and to teach in a digital environment requires not only a minimal mastering of collaboration tools such as Microsoft Teams, Google Meet, and learning platform such as Moodle but also requires the ability to deal with online information. In a world that is rapidly embracing digital technology, students and teachers need to be able to gather and use online information critically (OECD 2015). Gaps in the digital skills of teachers and students must be considered to reduce the wedge between expectations and reality.

2.4 Didactic barrier: Failing to choose an appropriate educational scenario

From objectives to learning outcomes, from learned competencies to assessment, from colors of interfaces to the learning experience, the educational scenario of a teaching module is a whole system to be imagined and set up in a coherent logic.

Integrating digital tools is more than another refit in the learning context. Indeed, the forced remote conditions during the pandemic showed that in a digital environment, thinking about the educational scenario is even more important than in traditional learning (OECD 2015). The articulation of different learning modes (asynchronous and synchronous) seems to be a key success factor of the learning experience in the context of intensive use of digital technologies (Vielma and Brey 2021). Failing to choose an appropriate articulation between the pedagogical approaches, the communication strategy, and the learning modes leads only to the addition of 21st-century technologies to 20th-century teaching practices. This failure will dilute the effectiveness of teaching.

2.5 Financial barrier: The costs of the digital transformation

Digital transformations are expensive (Wade and Shan 2020). A global approach involving public authorities and private sectors should be conducted to study the coverage of these costs. During COVID-19, the first impediment to working from home arose from the need for material support. Indeed, the question of who bears the cost of setting up the integration means of digital technologies to implement remote work was raised (Thornton 2021). The intensive use of new technologies for work and learning can price out individuals who cannot afford the technologies (Grand-Clement et. al. 2017). In the learning context, these costs may not be the burden of educational organizations alone but shared across ministries to better reflect the reality of the needs for digital learning throughout a person's life (Grand-Clement et. al. 2017).

3 METHODOLOGY

We adopted a quantitative and qualitative abductive approach through a case study of a French public engineering school, with around 600 learners divided into three levels and where practical works account for 47% of teaching hours and 28% of the teaching hours are based on the problem- and project-based learning approaches. To address our research objective, we developed a three-phase methodology. The first phase aimed to identify, understand, and structure the barriers to learning created by the COVID-19 crisis. This work allowed us to propose a taxonomy for the identified barriers presented in the second section of this paper. In the second phase, we audited and contextualized the identified barriers. The outcome of this phase was a matrix where the presence of the identified barrier categories is checked and contextualized.

Table 1. Overview of the used surveys

| Survey period | May 13-28, 2020 | Feb. 8-March 1, 2021 | May 26-June 4, 2021 |
|----------------------|--|---|--|
| Department in charge | Learners' Affairs Department (LAD) | Educational Innovation Unit (EIU) | LAD and EIU |
| Objectives | Feedback on the remote learning experience | Feedback on teaching practices in the COVID-19 period | Feedback on the learning experience in the COVID-19 period |
| Target | Learners | Teachers | Learners |
| Target size | 419 | 48 | 610 |
| Number of answers | 315 | 26 | 212 |
| Answers (%) | 75% | 54% | 35% |

Table 1 presents an overview of the list of the surveys conducted from May 2020 to June 2021 to audit and contextualize the learning barriers, knowing that the situation

evolved from fully imposed remote activities from March to June 2020 to a mix of fully online and blended learning from October 2020 to June 2021.

The third phase of our methodology consisted of a 75 minutes workgroup. This workgroup was twofold. The first target was to grasp the teachers' feedback on the barriers encountered during the pandemic crisis. The second target was to formulate propositions of must-do actions.

The workgroup was composed of 8 participants (teachers and teacher-researchers). The sample of participants was constructed to meet three criteria: (1) having more than six years of teaching experience, (2) having taught at least for three years before the COVID-19 crisis, and (3) being involved in a learning process with a strong digital dimension using PBL approach.

The discussions and exchanges were conducted according to a methodology based on a focus group (Simon 1999 ; Kitzinger 1994) for collecting qualitative data (Wilkinson 1998). Focus group is particularly adapted to explaining and exploring survey results (Kitzinger 1995). The work group was conducted using a guide where a predefined script is detailed. We opted for detailed note-taking due to the high risk of inhibition created by the potential recording of exchanges. Each of the authors made an individual content analysis. Three debriefing meetings were planned to compare individual analyses, formalize conclusions, and refine our proposal.

4 RESULTS

4.1 Audit and contextualization of the identified barriers in the literature

We fully observed the appearance of three (technical, anthropological, and didactic) of the five identified categories of barriers. The two remaining categories were partially observed. When a barrier was observed, we proceeded to its contextualization with facts from our field observation and data collection. Table 2 gives an overview of the results of the audit and contextualization of the identified barriers in the literature.

Table 2. Matrix barriers, audit, and contextualization

| The identified barriers | Audit | Contextualization for students | Contextualization for teachers |
|-------------------------------|-------|--|---|
| Technical barriers | Yes | <ul style="list-style-type: none"> ▪ Connection problems: 37% in 2020 (†) and 36 % in 2021 (*) of the interviewed learners reported that they had an “insufficient” internet connection ▪ Hardware problems: In 2021, 57% of the interviewed teachers reported that between 5% and 20% of their students were limited by their computer’s performance (●) ▪ Lack of a well-equipped environment: 36% in 2020 (†) and 31 % in 2021 (*) of the interviewed learners reported that they had no dedicated place to work at home | <ul style="list-style-type: none"> ▪ Connection problems: In 2021, 38% of teachers quoted connection issues among the issues they have faced (●) |
| Anthropologic barriers | Yes | <ul style="list-style-type: none"> ▪ Additional workload: In 2020, 56% of the interviewed learners had the feeling to work “more” or “much more” remotely than face-to-face (†). This rate decreases to 22% in the hybrid situation in 2021 (*) ▪ Reduced exchanges and social interactions were reported by students’ spontaneous statements and several free written statements made by teachers about students (●) | <ul style="list-style-type: none"> ▪ Additional workload: In 2021, 46% of the interviewed teachers pointed out the problem of work overload due to extra time needed to create or adjust their teaching materials. 40% of the interviewed teachers said that they recorded part of their courses (●) ▪ Impression of working all the time: In 2021, 27% of the interviewed teachers emphasized multiple and simultaneous requests from students, which increased their work time. 72% of the teachers interviewed quoted that they had to rephrase the students’ questions and interventions to be considered by all the students (●) ▪ Reduced work exchanges and social interactions: In 2021 58% of the interviewed teachers quoted isolation among the issues they faced (●) |

| | | | |
|--------------------------|----------------|---|---|
| Epistemic barrier | Yes, partially | <ul style="list-style-type: none"> ▪ Spontaneous statements from teachers about a systematic waste of time during online teaching to deal with problems related to the students' lack of digital skills. | <ul style="list-style-type: none"> ▪ Spontaneous statements from teachers about their difficulty in putting their teaching resources online via platforms and during online collaborative work due to their lack of mastery of digital tools such as Microsoft Teams, Google meet and Zoom Meetings |
| Didactic barrier | Yes | <ul style="list-style-type: none"> ▪ Necessity to be more autonomous and to change the way of work <ul style="list-style-type: none"> - In 2021, 28% of the interviewed learners declared that they had difficulties to organize their work time (*) - In 2021, 15% of the interviewed learners declared that they had difficulties to find resources and to do work on online platforms (*) - In 2021, 35% of the interviewed learners declared that they had difficulties to work independently and 34% of the interviewed learners needed more assistance from teachers (*) | <ul style="list-style-type: none"> ▪ Necessity to rethink the educational scenario to better integrate remote learning <ul style="list-style-type: none"> - In 2021, 62% of the interviewed teachers reported that they would continue to change some of their teaching resources after the lockdown periods. 36% of the interviewed teachers quoted that they are ready to adjust between 25% and 100% of their teaching resources (●) - In 2021, 65% of the teachers said that they would create new "short contents" if "recording, editing and content creation equipment were available" (●) |
| Financial barrier | Yes, partially | <ul style="list-style-type: none"> ▪ Inability to afford adequate equipment: Two internet connection keys and 23 personal computers have been made available by the school to learners | <ul style="list-style-type: none"> ▪ Additional expenses: In 2021, 62 % of the interviewed teachers reported that they would need a new headset (●) |

(†): Survey (May 13-28, 2020), conducted among learners by the Learners' Affairs Department

(*): Survey (May 26-June 4, 2021), conducted among learners by the Learners' Affairs Department and the Educational Innovation Unit

(●): Survey (Feb. 8-March 1, 2021), conducted among teachers by the Educational Innovation Unit

4.2 Workgroup's feedback and proposition of three must-do actions

The participants in the workgroup admitted that the possibility of partly monitoring the learning process of PBL remotely allows to increase the frequency of exchange with students. This leaves room for students' greater autonomy. As the student manages the teacher solicitation rhythm, he becomes an actor in his learning process.

One of the main convergence points which emerged from discussions was that the students who had experienced the start of their problem-based work group in the classroom kept the principles of exchange and mutual aid between groups in the intensive digital context. Nevertheless, the members of the groups who started their projects during the lockdown tended to remain self-contained and not collaborate or exchange with other groups. The participants believe that the lack of interaction has affected the students' awareness of their competencies and their self-assessment progress. The effectiveness of learning via screens seems to depend on the sequence of the educational scenario. In other words, face-to-face session to stimulate the intra-group connection is a success factor in the implementation of the problem-based learning pedagogical approach in digital context learning. Participants claimed that customizing the process based on the user needs is a key success factor for learning in a digital context process. Creating the same learning process for all to increase accessibility may hamper inclusivity.

The work group identified three must-do actions to contribute to ensuring better quality and resilience of the future learning process: (A) develop the ability to learn, (B) develop agility, and (C) empower teachers and students. The participants highlighted that decision-makers must invest in capacity development and change management to develop these three actions in the post-covid world.

Develop the ability to learn

In our complex, modern, and rapidly changing world, the one true constant is change. Individuals and organizations need to be ready to face any wave of change or disruption at any time. The first key asset to be developed to face a world shaped by fast-changing digital technologies is the ability to learn and adapt its competencies. Learning how to learn is a meta-skill that organizations, individuals, and, more particularly, teachers need to face the continuous change in their environment. Teachers have the responsibility to ensure the adequacy of the students' competencies to the need of the workplace. They themselves must keep their competencies up to date probably more than any other profession. Developing students' ability to learn by providing resources to be consulted individually has two advantages. Firstly, it allows students to have access to the

resource at their own pace. Secondly, it gives them a sense of responsibility in the learning process. Developing the ability to learn can lead to a more customized learning process if the educational scenario is well-planned. Participants in the workgroup insisted heavily on the fact that the actions to be done and the objectives to be reached by the students must be set in advance to avoid “losing” them. They claimed that the risk they fear the most is that students spend their time zapping from one resource to another. Indeed, building a learning mindset is not an easy task. It can also trigger fear and temptation to fall back on familiar solutions that worked before if the learning process has not been well planned and instrumented.

Develop agility

The participants highlighted that to exist in tomorrow's world, we need agility to cope with change. Agility will allow the needed flexibility and pragmatism to adjust to the expected or unexpected changes in the shortest time span. Indeed, the teachers reported that the health crisis has forced the educational community to be agile. They have had to step out of their comfort zones and explore other forms of teaching. The pedagogical proposals offered to students are now much more varied. Throughout the week, they will follow classical courses, problem-based teaching, flipped classes, and autonomous teaching sessions. Capitalizing on it to improve agility is mandatory. For instance, the creation of video nuggets allowing the technical handling of software and intuitive procedure to explain how to take control of students' computers remotely are possibilities cited to foster agility.

Empower Teachers and Students

The participants in the workgroup highlighted that, in the learning process, empowering teachers and students is an important driver: it is vital that they must be given the means to become active agents for change. Teachers must go beyond just implementing technological innovations and design innovative educational scenarios. Students must be put at the heart of the learning process.

Participants also highlighted that the technical dimension of learned concepts and didactic difficulties led them to rethink their way of approaching the notions with the constraint of learning in a digital context. They, thus, had to create new supports or make the existing ones evolve by considering the prism of the student alone facing the learning resource. An effort to integrate all the notions given usually orally in the classroom was necessary. Many teachers felt the need to integrate videos or hybrid solutions (written resources and links to video nuggets) in their educational scenario during and after the COVID-19 crisis. They emphasized the great need for support in planning and instrumenting during the educational scenario upgrade process. Involving users (teachers and students) in the implementation of the change increases their sense of belonging and commitment which is a form of collective empowerment.

5 SUMMARY AND ACKNOWLEDGEMENT

Our methodology allowed us to find out three out of five barriers defined in the presented taxonomy. We audited them by analysing students and teachers feedback. From that, we proposed a set of must-do actions in order to develop the ability to learn, develop agility, and empower teachers and students.

We thank teachers and learners who made this study and this paper possible.

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