

The Use of Interactive Technologies for Education in Pandemic and Post-Pandemic Contexts: Design Implications

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ABSTRACT

This study investigates COVID-19's impact on the education system. It captures a multidimensional representation of teachers, students, and parents' use of information communication technologies (ICTs) to mitigate this disruption caused by school closures. The study analyzes the evolving influences on individual and collective behaviour amid the pandemic. The methods consisted of a 5-week longitudinal study that included a survey and multiple interviews with the three stakeholder groups. The qualitative and quantitative data yielded the analysis of ICTs usage before and during social confinement. Further to our analysis, we categorize and discuss our findings. We also interpret results to capture design implications and generate a new concept for design. To finalize, we identified students' learning loss and learning variability as pressing issues, despite the availability of technological mediums. We believe that a collaborative learning system could mitigate such a challenge. We believe that such a system could connect students to a teaching community and imbue a sense of togetherness within the context of distance education.

CCS CONCEPTS

• **Applied computing** → Education; Collaborative learning; • **Human-centered computing** → Human computer interaction (HCI); Empirical studies in HCI.

KEYWORDS

HCI in the Pandemic, distance education, students learning variability, children's learning development, computer-supported collaborative education

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1 INTRODUCTION

According to UNESCO [1], compulsory confinement as a response to the COVID-19 pandemic [2], [3] and the consequent school closures affected 94% of the world's student population with uncertain impacts. That is, 1.6 billion learners had their learning process interrupted when the pandemic rose to its maximum, turning into the most significant disturbance in the school system known in history. This issue seems to aggravate previous inequalities in education, especially for the students without a good parental support system, living in poor or rural areas, female students, or children with disabilities [4].

UN's Policy Brief [4] informs that the majority of the almost 190 affected countries made an abrupt change in the choice of instructional methodologies, from face-to-face (F2F) to Distance Education (DE). New procedures were implemented to guarantee the continuity of teaching and learning, despite the lengthy discussion on the benefits of such methods for students' learning, especially during school closure periods. Nevertheless, the UN refers that approximately 40% of the impoverished nations were unsuccessful in promoting supportive measures to at-home students amid the COVID-19 pandemic. Still, in most countries, the school system adopted new standards and whereby teachers had to swiftly adapt their learning approaches to accommodate DE and bridge the physical gap between schools and students.

Recourse to DE amid the 2020 pandemic brought an increased awareness of the importance of ICTs, their adoption, access, and knowledge as a tool to increase openness and accessibility to educational systems and school communities. It also urged the need to grant access to a fair learning environment for all students, regardless of their background. Certain inequalities were, before the pandemic, partially balanced within the school setting as children would have access to similar resources and equipment, even though the literature on the 'homework gap' already exposed the negative impact of socioeconomic background on student performance. So, during the pandemic, lack of means was not mitigated. For disadvantaged students, learning did not progress as much as for more resourceful students [5], [6].

2 BACKGROUND AND RELATED WORK

This section will provide background information on our longitudinal study, followed by a reference to the related literature and a presentation of the resulting research questions. The longitudinal study seeks to understand how three stakeholder groups coped and adapted to the online transition of the education system, focusing on students' learning progression and educational needs. Additionally, we examine when and how participants adopted ICTs to progress their educational activities remotely. Distance education

has shifted from asynchronous learning via email to synchronous e-learning, peer instruction platforms [7], [8]. Although DE is used as an umbrella term for learning at a distance, it is important to note that the term Virtual School (VS) has also gained momentum [9]. In the past, education systems have often resorted to novel technological mediums to assist instruction. However, in the pandemic context, education aided by virtual tools was pushed to its total capacity, and regularly, unlike before [10], [11].

2.1 Research context

This research was conducted in Portugal between April 1st and May 4th. During this period, we collected responses from the three groups of education stakeholders amid the school closures in early 2020. The sudden transition from F2F to DE was particularly demanding on district and school employees, causing "high levels of burnout" [12] as they tried to continue the student's learning process. Early solutions to progress school instruction were incipient, most developed gradually, even though the potential risk of more than 23.8 million children and young people's inability to cope with the school closures was a cause for great concern. Also, the further lack of interest, which could lead to school disengagement, was concerning, according to OECD [13] and the United Nations (UN) [4]. Such complex issues could erode student attendance and learning pace as well as originate a diverse set of learning needs. Therefore, it became imperative for educational systems to assess ways to re-engage students, address learning variability, and encourage a continuation of their educational aspirations.

2.1.1 Research void in K-12 Education amid the pandemic. Well-informed decision making during a pandemic is paramount to its management. This type of information is often rare, deficient, dispersed and "mainly addressed in 'medical' journals and more recently boosted by the 'knowledge management' scholars" [14]. Additionally, other studies examine the issue from the perspective of macroeconomic effects on regions affected by pandemics or near-pandemics. Although disaster management is fundamental, the disease outbreak is distinct from earthquakes, snow hazards, fires, or floods due to its particular and important 'dynamics' [14]. Research on the effects of a myriad of events on school closures, such as weather-related phenomena (e.g., Hurricane Katrina in New Orleans), although not as disruptive as COVID-19, provide insights on the correlation between student achievement and the time spent at home without access to a physical school environment [5].

According to Kuhfeld et al., the scarce comparative research on F2F learning and DE is inconclusive. Simultaneously, some studies found adverse effects on student's Virtual Learning (VL). While others found zero or minimal benefits in DE compared to F2F instruction, even though Covid-19 presents aggravated issues [5]. For others, studies and debates on the technology role and distance educational media of the past 60 years lack robustness, leading to "unrealistic claims about the impact of technology on learning" [9].

2.1.2 Education consequences amid a Pandemic. The UN claims that instructional loss will occur and jeopardize the effort of many decades, especially for underprivileged children and adults, mostly young girls and women, whose learning opportunities diminished due to the pandemic [4]. The OECD refers to other authors who

allude to the minor effects of school closures in students' achievements, found in the literature; namely, the prolonged school closure period 2011 derived from Christchurch earthquakes, this considering that teachers later concentrated on what students should learn. Although shorter in duration, such closures happened suddenly and disturbed the learning process; therefore, it might pose similar consequences in the school system and how the learning process should continue [13], [15].

Albeit insightful, Kuhfeld et al. refer that some of these studies could have several flaws, like not studying the impact on different demographics, socioeconomic context, or the impact of the current technological solutions used for remote learning. Another critical issue is the impact of wave patterns of SARS-CoV-2's reinfection in certain areas or populations. In this case, the correlation now being made between lost time and its impact on learning with s might not be entirely accurate tomorrow. Therefore, the authors conclude that student's accomplishments are difficult to determine in such a climate and its impacts on their academic future [5].

2.2 Learning loss and variability among students

Despite the constraints and shortcomings imposed by DE methods, "students who did not receive online instruction may have gotten no instruction at all" [5]. In fact, according to Chen et al., most Chinese public K-12 schools, like the ones present in this study, "did not have dedicated platforms and devices or online teaching and learning experience" [16] due to their lack of resources. Many teachers and students had to find "their own ways to deal with challenges in such an urgent transition" [16]. For example, the Education Trust (ET) refers that schools in high-poverty areas were not inclined to provide online learning, especially synchronous teaching, and referred to a complete absence of a more significant number of students than low-poverty schools. Some authors make a correlation between DE and participation decline and absenteeism challenges [16]. Evidence emphasized by the American Enterprise Institute (AEI), which refers to solely one-fifth of American school districts reached high standards for their DE approach. Leading to a national understanding from teachers that their students "spent half as much time on learning they did before the COVID-19 school closures" [5].

Europe, 5% to 8% of the French students were unsuccessful in interacting with their teachers two weeks after school closures. While in the USA, there is evidence of complete disconnection between teachers and their students, wherein early April, 39% of educators contacted, every day, mainly by email, their students. Also, in the second-largest school district of the USA, Los Angeles, approximately 13% of students failed to reach teachers and their schools.

Kuhfeld et al. project student learning loss and learning variability, during COVID-19, in line with summer learning gaps, resembling a lengthened out-of-school period and considers the possibility of future decreased learning gains. Namely, reduced academic achievement will cause greater variability in students' average school gains in the next school year than in former years due to the unequal support from teachers and/or parents and relatives. Moreover, in the abridged school year, students are expected to have

between "63% and 68% of learning gains in reading, but only 37% to 50% of the average gains in mathematics" [5], while 30% of students were absent during the same period. Some experts' projections, based on prior studies about critical periods and their aftermath, the post-COVID-19 time will bring not only a rise in child poverty but also in school abandonment. [13], [17] It seems that both issues continue to be inseparable despite the technological progress we witness today.

2.3 Student's familial and socioeconomic background

According to Miller and Ashdown, the misunderstanding of the "socioeconomics that many students face may result in them failing" [18] to complete their school year successfully. Even though the school system tried to cope with the tempestuous process, many "students and their families likely bore the brunt of the responsibility for ensuring that learning continued during the closures" [5]. Some parents with low education who could not aid their children's school duties resorted to their children's older siblings, other family members, or acquaintances. According to the ET, the subsequent low achievement of students may also be due to the lack of access to ICTs that affected 50% of low-income families. Moreover, the loss of the household income and the cut of nutritious meals added to the students "struggle to meet the academic year's outcome goals after the reduction in educational time" [18].

The parents who kept their jobs were also conflicted to balance their work, remote or not, with their children's needs, as in another stress factor that will alter their academic accomplishments. The student's caregivers became their children's learning supporters and their motivators amid such crises. The OECD's studies indicate that 95% of Korean students referred to their parental learning and emotional support to cope in this stressful period, which is 6% higher than the OECD average. While in Portugal it is 94%, the USA (United States of America) and Australia is 93%, in the UK (United Kingdom) is 92%, Sweden and Japan with 89%, Chile with 87%, Turkey with 87% and Germany with 86%. [13], [15], [17].

After examining the above literature, we observed insufficient research on learning loss and learning variability associated with education's inequalities during a pandemic event. Students' socioeconomic background and school's location were found to be essential to a quasi-normal progression of instruction on a disruptive phenomenon like the Covid-19 pandemic and the consequent school closure. Despite the discussions on the effectiveness of DE, a complete lack of school engagement due to absent widespread technological infrastructure and resources associated with disfavored backgrounds and inability to be assisted seem to emphasize previous learning inequalities.

In response to the above presentation of key literature, our study aims to comprehend how the school system adapted to the sharp transition by examining teachers, students and parents' adaptability and significant concerns and coping strategies. Therefore, we suggest the following research questions:

RQ1: What challenges did 8th-grade teachers, students, and parents face when transitioning from F2F to DE, supported by ICTs?

RQ2: How did they address such challenges?

RQ3: What unforeseen challenges arose in teachers, students, and parents' use of ICTs during school closure? Were they able to tackle such challenges?

3 METHOD

3.1 Procedure and Data collection

Due to the complexity of the unexpected education's methodological transition, the researchers applied a mixed-method quantitative-qualitative procedure. From multiple perspectives, although anecdotal, we aim to "shed light on a concept or more likely several concepts and how they are connected" [19]. This procedure allows cross-examining the survey's data, which defined the interview's design. Moreover, this mix-method approach enabled examining the stakeholder's individual and collective experiences throughout five weeks. The period comprehended the school closures at the end of the second term and the beginning of the third term, intermediated, in some cases, by an extended break. The goal is to investigate the overall reactions to school closures and the digital interactive strategies employed to continue the instruction. The longitudinal design allows, as well as the registration of behavioural and strategic modifications "in critical moments of change and transitions" [20], [21].

3.1.1 Survey. This study started with three surveys to three education stakeholders – teachers, students, and parents. The questionnaires' links were published separately in social media channels, targeting the specific stakeholder, namely teachers' Facebook pages, in April's 2020 first fortnight. The surveyed subjects (N=215) were composed of 79% of teachers, 4.7% of students, and 16.3% of parents living in Portugal. The respondents varied from different ages, school levels, institutions (private and public), and geographical areas. The goal was to understand the complexity of the school closure due to the Covid-19 phenomenon and ultimately narrow the research scope.

The survey has served as the base for the questionnaires' theoretical and design application of longitudinal semi-structured interviews [19], [20], [22]. The teacher's significant participation in the survey provided a more precise direction to the interview design, centred around questions regarding teacher's perceptions of student learning engagement and content apprehension. In contrast, for the other stakeholders, the initial interviews were more exploratory. The student's understanding of their learning needs and parental assistance was fundamental to assessing a more comprehensive depiction, processes, and outcomes to be examined.

3.1.2 Interviews. The longitudinal study comprised a set of semi-structured interviews that, regardless of the period it occurs, "can capture elements of change and still allow for degrees of reflexivity" [23], thus enabling an iterative and exploratory environment [24], [25].

The recruitment of the interviewees (N=6) focused on 8th-grade teachers and students and parents with children enrolled in the same grade as well. The convenient and purposeful sample was selected using a cluster sampling and design thinking extreme user method [26]. The concentration on the extremes allows the surge of aggravated problems, requirements, and procedures. The cluster sampling comprehended four schools in the public and

Table 1: Interviews' participants

ID	Stakeholder	Age	Gender
T1	Teacher	48	M
T2	Teacher	43	F
S1	Student	14	M
S2	Student	15	M
P1	Parent	41	F
P2	Parent	42	F

^a Educational stakeholders' succinct information.

private sector, dispersed geographically all over three cities (rural and urban areas), with comparatively different households. Table 1 presents information relating to each interviewee. When recruiting parents, we used the same method to select working and stay-at-home parents with diverse academic profiles [19], [23], [27].

The six stakeholders were interviewed individually once a week, via Zoom or telephone, throughout five weeks, for an estimated period between 13 and 21 minutes. The 30 interviews were recorded upon request, noted and transcribed. We asked participants about the challenges they faced up to that interview and how they addressed them. Moreover, we were particularly interested in participants' knowledge and insights concerning DE, and its implementation throughout the study, since the survey showed conflicting data. We also questioned interviewees about their resources (existent or not) to support DE. We wanted to learn how they used resources during school closure. Additionally, we assessed participants' assistance, or lack of, to aid remote learning or further understand learning content and material.

3.2 Data examination

The transcribed interviews were analyzed to design a new set of questions directed at participants in the following week. After the 30 interviews' cycle, we carried out an in-depth qualitative examination using feature coding to assess trends in DE. The leading author carried out the analysis by carefully reading the transcripts and manually coded the data into eleven codes consisting of: "Feelings and Perceptions", "Homework", "Student's Assistance", "Group Activities", "Classes' Structure", "Learning Methods", "Technology", "Social Media", "Communication", "Institutional Communication" and "Tele school". A group of meaningful thematic clusters emerged from the set analysis according to their "similarities and dissimilarities on various dimensions" [28], using a collaborative visual platform [29]. This analysis stressed the need for "Collaborative" assistance on a methodological and procedural level in addition to the need for more "Autonomy" aligned with an "Extrinsic and Intrinsic Motivation" to carry on the instructional activities despite the stress and anxiety motivated by the uncertainty.

Afterwards, we created a theme analysis to understand observed modifications in participants attitudes and behaviours towards DE practices and methods. Three major trends emerged: "Education Duties" often associated with overwhelming feelings regarding the new responsibilities and the inability to perform without support. In addition, "Interactive Technologies" were acknowledged as a fundamental tool to maintain school instruction despite the unequal

distribution and/or experience among the school population. However, potentialities also emerged, primarily due to the interactive qualities of online teaching and learning and its ability to bring people together. "Communication", both institutional and informal, were paramount to address the uncertainties and the changeable atmosphere where the participants were living. Initial scarce or inexistent communication, mainly in the public sector, progressively changed to a more direct exchange of information as soon as schools and educational authorities provided guidelines.

4 FINDINGS

We observed the stakeholder's perceptions during the transitional period, from an initial confusion and anxious state due to the uncertainty regarding the school progression to a more contempt towards the end of the study. The general understanding of digital media as a medium solely for entertainment shifted due to education's digitalization advancement. The Covid-19 pandemic revealed preconceived notions of children's exposure to the digital tools, now used for communication and learning purposes. Antle and Frauenberger address the need to paint "a more nuanced picture of children's experiences with digital technologies" [30] and contextualize them holistically.

This section provides answers to RQ1 and RQ2 and contributes some design directions. These guidelines might derive from COVID-19's response and how this knowledge can be used to evaluate new forms "of teaching and the methods and strategies" (T1) that can be used to structure a new system. (T1, T2) Therefore, it is fundamental to level the playing field by assessing the available resources and ensure technological equity (T1, T2, S1, S2, P1, P2) and respond accordingly.

4.1 Teachers' coping strategies for an unprepared DE role

Learning progression: According to the examined data, teachers and pupils interacted through ICTs, namely through the email used to deliver weekly assignments and clarify doubts. 84.1% of surveyed teachers agreed that their students were not learning as much as in F2F instruction. Also, they saw a quality decrease in students' assignments, driving them to lower their expectations. In addition, teachers stated that "this is a very extraordinary moment in our lives, and we all are doing our best" (T2). The student's participation in synchronous classes also declined because "there's no comparison between expressing verbally and clear a student's doubts using a chat, for students to see, when or if they see it" (T2).

Technical and methodological: Survey results indicate that 87.6% of teachers felt that they were not fully prepared, nor did they possess the essential training required for DE. Teachers acknowledged a lack of preparedness during interviews as well. To mitigate this gap, most teachers resorted to colleagues, either formally or informally, through email or social media groups; this indicates that the provision of more explicit instructions should accompany continuous teacher training in the use of ICTs in the context of DE. We believe this should apply to students as well. Continual tech support and training, in several formats, must be granted as well to aid the school community.

Out of the school support: According to 58.2% of surveyed teachers, parents' participation has not expanded during school closure. The more engaged parents were helping students in their tasks, while others were "not be able to support the student's needs, and many other needs" (T2). Moreover, T2 claims this crisis "will only emphasize some inequalities that we must face as a society."

4.2 Students' learning challenges during the pandemic

Communication gap: The survey informs that 60% of the student's interactions with teachers were made mainly through interactive communication systems like email and social media groups in Messenger or Instagram. Although 90% of surveyed students learned that the remaining school year would progress through their teachers, most felt they were not entirely informed about it.

Learning progression: synchronous classes, 70% of pupils were not as participative, and 80% agreed that queries were not fully clarified during DE sessions. Moreover, some students did not feel entirely accompanied by their teachers, an issue emphasized by S1 and S2, which led 80% of them to conclude they were learning less than before the pandemic. A minority of surveyed students attending a private school, like S1, were "satisfied" with the use of DE methods and found video conference classes "cool", yet they would "like it more if it were face-to-face" (S1). While S2, attending a public school in a poor district area, did not have synchronous classes nor had access to an interactive digital learning platform and was told to see tele-school broadcasted on a public channel. (S2) For T2, synchronous video conference classes facilitate the "proximity between students", and it seems to "draws more of their attention" (P2). So, a class protocol could include 45 minutes of extended classes to promote student's participation in the last 15 minutes. This extended time could serve students to comment on each other's work via constructive feedback and insightful suggestions (T1, S1).

Out of the school support: The students affirm that the weekly homework plans were initially overwhelming. Still, students changed their approach, gradually becoming more proactive and autonomous. (S1, S2) Our data also suggests that 80% of surveyed students claimed that their parent's help in their learning process did not increase, either for being overwhelmed with the new routines or for not being able to help due to a lack of knowledge. (S2) The insufficient support from teachers and parents often led some students to rely on siblings, the internet, friends, and colleagues in social media groups to "clarify some doubts (. . .) Or to check which pages on the worksheets they had to fill" (S1, S2). Nevertheless, we verified that some subject areas, like Math, were

harder to understand for students, like S2, especially in the context of DE, leading to a regression in learning gains.

4.3 Parents' struggles for an enhanced educational role

Communication gap: Parents' need to increase their involvement in their children's learning process during school closure was not entirely or only partially communicated (42.9%). Some parents claim their offspring's teachers did not say "anything, no one says anything" (P2) about their new tutoring responsibilities. Additionally, 54.3% of surveyed parents were not enlightened about DE and how it would be conducted. As a result, 68.6% relied on social media and social media groups for more information. This challenge was dealt with similarly by interviewed participants.

Learning progression: Data retrieved from the survey indicates that 60% of parents consider their children were not learning as much as F2F learning. Although 94.3% of them affirmed there was no interruption in the student's educational progression, others worried about the inexistent school/student interaction. Furthermore, teachers stated that students' queries and doubts were not entirely clarified during school closure, nor the schools were providing the necessary pedagogical support.

Out of school support: the perceived struggle on behalf of students, 45.7% of surveyed parents maintained a similar degree of involvement in their children's school duties. While 28.6% saw their involvement grow slightly and for 25.7%, their assistance for their children enhanced in some cases to more than 90 minutes per day. Despite the expanded role in their children's learning process, 57.1% of surveyed parents believe that they were not fully capable of clarifying their educator's doubts. Furthermore, P2's child "can't do his homework without his sister's support" (P2). Meanwhile, P1's child "asks for less each time. But yes, he occasionally asks me for help" (P1).

It takes a virtual village: To mitigate the inability to assist their children, 28.6% of parents joined a social media group, where 60% of them went more than five times per week. Our survey suggests that 50% of the interactions in parent social media groups were about student's homework and ways to assist it. Similarly to pupils, parents found social media groups pertinent and helpful, particularly to those who were "a little lost" (P1). It seems that "they ask for help on how to do something or where to do a certain thing. There is usually always a person who responds" (P1). However, P1 stresses the importance of these groups is diluted by occasional "lack of objectivity" and overall "silliness". Furthermore, the insufficient time and embarrassment "to speak" (P2) meant that not all parents fully adhered to this solution. So, it would be pertinent to endorse the creation of a student, parent, and teacher group on an interactive communication platform chosen by them. But a set of contact standards and conduct norms among stakeholders must be developed to avoid miscommunication and inappropriate remarks or interactions (S1, P1).

Technical readiness: The acquisition of novel technological resources for DE was seen as unnecessary for 91.4% of inquired families, primarily due to the existence of school loans for technological resources. Local authorities' guidelines advised such loans

to in-need households. 65.7% already had all the necessary technical support to continue the student's learning process.

5 DESIGN IMPLICATIONS

This study reflects on the multitude of issues faced by the stakeholders and their use of ICTs to cope with the expected and unexpected issues found during school closure caused by the COVID-19 pandemic. Our longitudinal study used a mix-methods approach. As a result, the data analysis and its connection to the current literature resulted in suggestions with design implications to address students' need for a more supportive learning environment based on an ICT.

5.1 Community-assistive teaching

The ever-evolving ed-tech market presents several interactive products with an array of possibilities to choose from. These solutions combine pedagogical and design approaches that often result in materials for a mass audience and do not comprehend student specificity or the existence of learning variability or impairments.

The freedom brought by the recent technological innovations allows students to assume the "responsibility for managing their own learning, in such matters as deciding when they will study, how much they want to learn, and seeking out information and resources" [31] to build their intellectual structures. For this, students may resort to a less abstract learning process and prefer more human connection building on knowledge that can improve and be improved by "relationships with other people encountered in the learning process" [32]. Such a process exists in an educational community, that is, students will build their knowledge (academic or social) within a communal structure that will transmit "the repertoire of resources that the community has accumulated through its history of learning" [33] in a focused and personalized manner [33], [34].

5.2 Collaborative interpersonal learning system

As suggested by the study participants (T1, T2, S1, S2, P1, P2), an ideal system would be a crossed ICT platform between students and a teaching community (TC). ICTs could be an essential and strategic tool to facilitate those interactions, allowing articulation of an individual's actions enabling them "to navigate new ways to form social supports when they can't be face-to-face" [30]. This system would be easily accessed through a smartphone due to its extensive presence in classrooms (P1), so the student's specific learning losses could be easily and intuitively addressed.

Students claim to resort to search engines and social media groups to understand previously taught concepts to solve their homework, which might lead to further confusion and misunderstandings. As observed, such inaccuracies would not be addressed by a substantial number of parents due to their lack of knowledge. In this sense, the TC would help the students, in written or video format, synchronously or in an asynchronous manner. The interactions, mediated by interactive mediums, between the students and TC would be on an individual level, therefore reinforcing a culture that "can humanize learning by permitting more personal, less alienating relationships" [32]. Additionally, this system would

admit the existence of a small learning group as well, assisted by TC, and enhance the number of assigned group projects which will use collaborative tools to accomplish it (S1, S2). Besides, the involvement of a learning group of formal and informal interactions is fundamental for the overall learning experience. These learning formats would tackle learning loss and learning variability and would simultaneously forge fellowship among students and the community, thus promoting a healthy and amicable learning environment.

The human-centred approach to education, as recommended by the UN, could be beneficial in the pandemic's aftermath through the development of a 'close-knit community' of educators that could enable "peer interactions and discussion, work sharing, peer collaboration, peer feedback and peer assessment" [35]. The accredited instructors or TC would peer review the instruction given to students according to predetermined requirements and conduct norms among stakeholders to avoid miscommunication and inappropriate remarks or interactions (S1, P1). These members would need to individualize their instruction approach by understanding where students are academically and to sustain their learning continuity at a level and pace comfortable yet challenging to the student. Moreover, the TC could also enhance their distinct teaching approaches by supplying essential support to mitigate specific learning losses on behalf of students and nurture each learner's strengths.

6 LIMITATIONS

Even though this study tried to broaden the scope of research by reaching a wider variety of participants, the restrictions imposed by the COVID-19 pandemic proved to be challenging and resulted in difficulty to integrate more participants. In this sense, our sample is limited even though our analysis seeks to provide an ample perspective on the challenges encountered by stakeholders who experienced a diverse set of needs. This research was carried in a specific context, both geographically and in a pandemic situation; so, some of these findings may be linked with specific cultural conditions and therefore not applicable to other contexts. Future work may include a broader set of participants and stakeholders from different geographic, educational, and cultural stances to reach a more nuanced and enhanced understanding.

7 CONCLUSION

This longitudinal study shed light on the multi-faceted and often collaborative coping mechanisms of teachers, students, and parents when dealing with an unknown situation brought by the abrupt closure of schools. Initially, the sudden shift caused dismay and apprehension, among the stakeholders, due to the covid-19 uncertainty and lack of knowledge on how DE, aided by digital tools, would progress. Following our data analysis, the adaptation of stakeholders to such circumstances gradually led to a greater collective understanding of how they could cope with the situation and accept the limitations imposed by the pandemic. Additionally, we noticed, and the stakeholders as well, the pervasive use of ICTs in education during school closure. Nonetheless, we also identified underlying issues that reveal several weaknesses: the lack of support some students face at home once adhering to DE.

According to our study, many students were affected by the inadequate response of the education system, which many parents could not compensate for as they could not correctly assist their children's educational needs. Consequently, student learning loss and learning variability will likely stand out as pressing matters post-pandemic. Once we concluded data examination, it became apparent that there was a demand for a flexible system that could tackle students' distinct requirements. As a result, our proposed design implications project a system that could answer students' pedagogical needs whilst nurturing the creation and maintenance of teaching-enabling communities.

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