



# Enabling Genuine Connections in a Digital Learning Environment for Students Through Information Communication Technologies

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**Abstract.** This study introduces initial results concerning a collaborative learning mobile application to mitigate 8th-grade students' learning loss and learning variability. COVID-19's impact on the education system and its shortcomings before, during and after the pandemic was the starting point of this study. The interactive system's concept and design are derived from a collaborative reflection expressed on the school community's daily needs while teaching and learning during the unpredictable circumstances created by the pandemic. Also, by a state-of-the-art comparison of the scarce K-12 e-mentoring systems in combination with the ubiquitousness of various technological mediums, namely mobile devices like smartphones, and their fundamental role in e-mentoring programs could create successful bonds based on knowledge transmission. The OWL CLUB mobile application seeks to curate the knowledge exchange in a more humane and positive digital experience in an educational community. It also allows for creating and growing a space that encourages new genuine connections in a digital positive learning environment for students and their community.

**Keywords:** Research design · HCI · Technologies information · Students' learning loss · Computer-supported collaborative education · Technology-Enhanced Learning and HCI

## 1 Introduction

The COVID-19 pandemic's impact and the consequent lockdown and self-isolation measures to limit the virus' spread resulted in school closures in more than 190 countries by mid-April, thus impacting 94% of the world's student population [1–3]. The inability to meet face-to-face (F2F) with teachers and classmates was mitigated by Distance Education (DE) through Information Communication Technologies (ICTs), now playing an essential role in maintaining some of the prior bonds [3]. According to the United

Nations (UN), most countries implemented DE guidelines to support students' learning progression, amid the pandemic, except almost 40% of least-developed nations [4, 5].

Communication is an essential element of learning, which is intrinsically assumed as F2F, now happening with the student(s) and teacher(s) separated physically and temporally. Therefore, the interaction between teacher(s) and student(s) could be intermediated by certain mediums, usually linked to the time's dominant communication technology. Throughout the pandemic, school systems adopted different strategies to deal with the lockdown; however, discussions on the rapid implementation of DE solutions gained extra arguments as the situation escalated. DE is not consensual due to the ongoing apprehension of its methods as a valid and effective educational approach, even though former comparisons with the F2F methods proved inconclusive or marginally better. Research on disruptive phenomena in the education system is scarce. Still, events like Hurricane Katrina "can provide a rough sense of how additional time out of school" [6] will reflect on students and how the educational process continues. Yet, a distinction must be made between a disease outbreak and hurricanes, earthquakes, or snow hazards due to their dynamics and possible recurring nature [7, 8].

Current research alludes to the exacerbated academic disparities across the socio-economically disadvantaged families and socio-cultural minorities that will aggravate amid the pandemic [1, 5, 7, 9]. The parents' lower education impedes them from properly assisting their children, emphasizing the inequalities, leading to increased learning impairments and school abandonment [2, 3, 10–13]. Disruptions in education and the consequent "loss of previously acquired knowledge and skills" [14], although acknowledged by the education research community, are not entirely consensual. The Summer Learning Loss (SLL) in American students might predict COVID-19's learning disturbance [1, 15]. Kuhfeld et al. [6] identify pervasive shortcomings among SLL studies, like the lack of impact on different demographics, impoverished communities or the new technological mediums used in DE. Also, Atteberry and McEachin [16] observed that in addition to the students' varied learning gains throughout the school year, SLL emphasizes more academic accomplishments than school years, therefore, school settings diminish inequality growth and learning variability [16–18].

Our proposed e-mentoring app system, the OWL CLUB app, seeks to address specific learning issues, such as the student's learning loss and learning variability, in a community-centred manner. Its development was a continuous iterative design process grounded in the revised literature and the analyzed data from two F2F usability tests to ten 8th-grade students and ten adults. The qualitative and quantitative data were examined according to the content, theme and regression analysis, as well as through usability measuring tools like the System Usability Scale<sup>1</sup> and UEQ+<sup>2</sup>. The derived series of design iterations considered the quantitative and qualitative test analysis from the researchers' notes and users' remarks amid the tests and final questionnaire. The human-centred design approach and the behavioural data collected led to this system's refined concept and development.

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<sup>1</sup> <https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html>.

<sup>2</sup> <https://ueqplus.ueq-research.org/>.

## 2 E-mentoring as a Community Tool to Address Specific Needs

### 2.1 E-mentoring Method for Passing Need-Specific Knowledge

Humankind often resorted to the wiser individuals in their community for guidance, knowledge, and inspiration to achieve specific goals. When this relationship is auspicious, Dubois et al. [19] refer to the existence of five positive outcomes for the mentees in terms of “emotional/psychological, problem/high-risk behaviour, social competence, academic/educational, and career/employment” [20–23]. E-mentoring is a primarily computer-mediated mentorship [24]; that is, harnessed by web 2.0, e-mentoring overcame the offline setting where impartiality allows a more open, trustworthy, and flexible relationship in an informal manner. Like early mentoring programs, e-mentoring systems also seek to address similar issues like the lack of family support and the scarcely qualified mentors or role models nearby while addressing the low contact frequency due to geography or time constraints. Also, they can do so by reaching an essential informal virtual learning community, thus expanding their network and access to other information beyond a myriad of boundaries [21, 24–26].

Today’s digital connectivity offers “possibilities for keeping the distance student in touch with the institution’s student support services, in contact with learning materials and fellow students” [27]. The involvement of a learning group and the formal and informal interactions are indicated as fundamental for the overall learning experience and could support their supplemental learning needs. The freedom brought by the recent mobile technological innovations allows students to assume the “responsibility for managing their learning, in such matters as deciding when they will study, how much they want to learn and seeking out information and resources” [28] to build their intellectual structures. To create these structures, pupils may resort to a less abstract and more human connection with the knowledge to one that can improve and be improved by “relationships with other people encountered in the learning process” [29].

ICTs have been essential to knowledge democratization for the last two decades, thus improving educational possibilities in all education layers worldwide, thus granting new opportunities for the e-mentoring movement. The one-on-one mentoring solution has restraints, like the protégés’ loneliness and lack of timely feedback due to an over-reliance on one mentor, which does not aid the e-mentoring relationship’s growth. Additionally, some mentors allude to the uncomfortable feeling of helping in other disciplines. So, the presence of an online teaching community could help by sharing their knowledge efficiently due to the shared responsibility within specific guidelines [20, 30]. An e-mentoring closed social community system ensures a safe learning environment that allows spontaneous discussion. In the e-mentoring community, individuals see and examine each other’s social traces, personal interests, and activities on social media to get pertinent information and form bonds. The access to a broader group would ensure a diverse role model for mentees granting a sense of belonging [26, 31, 32].

## 2.2 E-mentoring DYAd's Process

**E-Mentee's Role and Outcomes.** Several studies found that mentees preferred to be assisted by a 'complete stranger' with no concealed reasons to assist or inspire them. The pairings must occur naturally, and the shared experience with a non-family role model focused on the youngsters' interests seems to kindle a pleasurable feeling linked to the companionship that grows between the participants. This bond contributes to the protégés' emotional and psychological well-being, a greater sense of self and confidence-building, adding to the knowledge and educational guidance. While in peer-to-peer settings, the equality and need for similar information make it more prone to rivalry and competitiveness rise [22, 30, 31, 33, 34].

The online format offers a safer environment and has the "potential to erode some of the traditional power dynamics that tend to structure mentoring relationships" [20]. The consequent impartiality permits the mentee to "share self-doubts, express concerns and ask 'silly questions,' in a way that is almost impossible when the mentee and mentor are from the same organization" [21]. According to Stoeger [26], the increased effectiveness of e-mentoring is related to mentee/mentor equal gender, which is especially pertinent to female students interested in STEM areas [22].

**E-Mentor's Role and Outcomes.** Even though the e-mentor's role is not recognized as a tutor or teacher, the education system acknowledges and implements this individual's actions. The e-mentor's function is to work alongside the e-mentee, structure the protégés' learning process through formal or informal settings, and successfully achieve their goals. The e-mentor acts as a positive and encouraging advocate of the e-mentees' learning progress and provides valuable insights in a 'boundaryless' and 'egalitarian' manner. Despite being different from the F2F setting, the e-mentor's assistance should be as fast as possible, in a positive, friendly, and honest way [20, 25, 33, 35]. Other known advantages include psychological and social benefits and deeper learning due to their knowledge reflections and consolidations by preparing for the instruction, affecting their regular practice [21, 36].

## 2.3 E-mentoring Challenges

E-mentoring is not a panacea for students' learning impairments and should not replace other forms of tutoring or F2F mentoring, but it could address specific needs and learning variabilities. Furthermore, the pervasiveness of several technological mediums and their essential role in e-mentoring programs are not synonymous with success. The explanation might be the "unenthusiastic response by individuals who are not technologically savvy" [24] and those who do not have the necessary resources to participate in such programs. Some authors emphasize the need for an awareness of the digital divide and its role in the lack of learning opportunities for the most disadvantaged students. Also, the possible malfunction, confidentiality and privacy challenges are essential issues to address [23, 25].

The lack of visual cues, like tone and body language in virtual communication, is considered disadvantageous to proper communication between participants, thus jeopardizing the efficacy of e-mentoring systems. A successful relationship requires some degree of virtual intimacy gained through the development of confidence and trust, which takes time to build. Videoconference tools and emoticons can mitigate these issues by conveying a few forms of social cues [24]. Some programs advise the mentors to foster the bond with the mentee by sharing personal experiences as a discussion starter. At the same time, others compel the participants to write a biography to share commonalities, strengthen their bond, and mitigate the gradual participant disengagement, both mentors and mentees [21, 30, 35].

### 3 E-mentoring Systems' Comparison

According to Bierema and Merriam [20], e-mentoring programs focused on K-12 are scarce, and the existing ones have timid attempts to address specific content. Additionally, Tinoco-Giraldo et al. [37] allude to the lack of mobile app systems that exclusively intermediate the mentor and mentee's relationship within the education realm, especially for the K-12 stage. Recently, e-mentoring systems are increasingly becoming hybrid web-based and mobile applications, like 'iCouldBe' [38], 'Math coach' [36], and 'Homework coach' [36] aimed at the K-12 demographics [39], as seen in Table 1. The new solutions can be used for learning support and flexibly increases the mentees' autonomy, considering the protégés' rhythm and learning methods.

Like 'iCouldBe', 'Math coach' and 'Homework coach', the OWL CLUB app seeks to aid students, including at-risk pupils. In addition, the analyzed e-mentoring systems' use of internal text-based asynchronous, for safety reasons, is seen as a pertinent feature to include in the OWL CLUB app, which could help the students pose relevant and structured questions and all participants engage collaboratively in discussions, allowing time to reflect and give proper feedback. But unlike the examined systems, the OWL CLUB app aims to address the students' learning losses and learning variabilities in a community-centred approach. The teaching community would support the student's specific learning needs through "humanized learning by permitting more personal, less alienating relationships" [29] while creating bonds in the process. That is, "the instruction in a human-centred manner, as praised by the UN, would therefore lead to a humanized learning environment" [40].

**Table 1.** Comparison between K-12 e-mentoring systems.

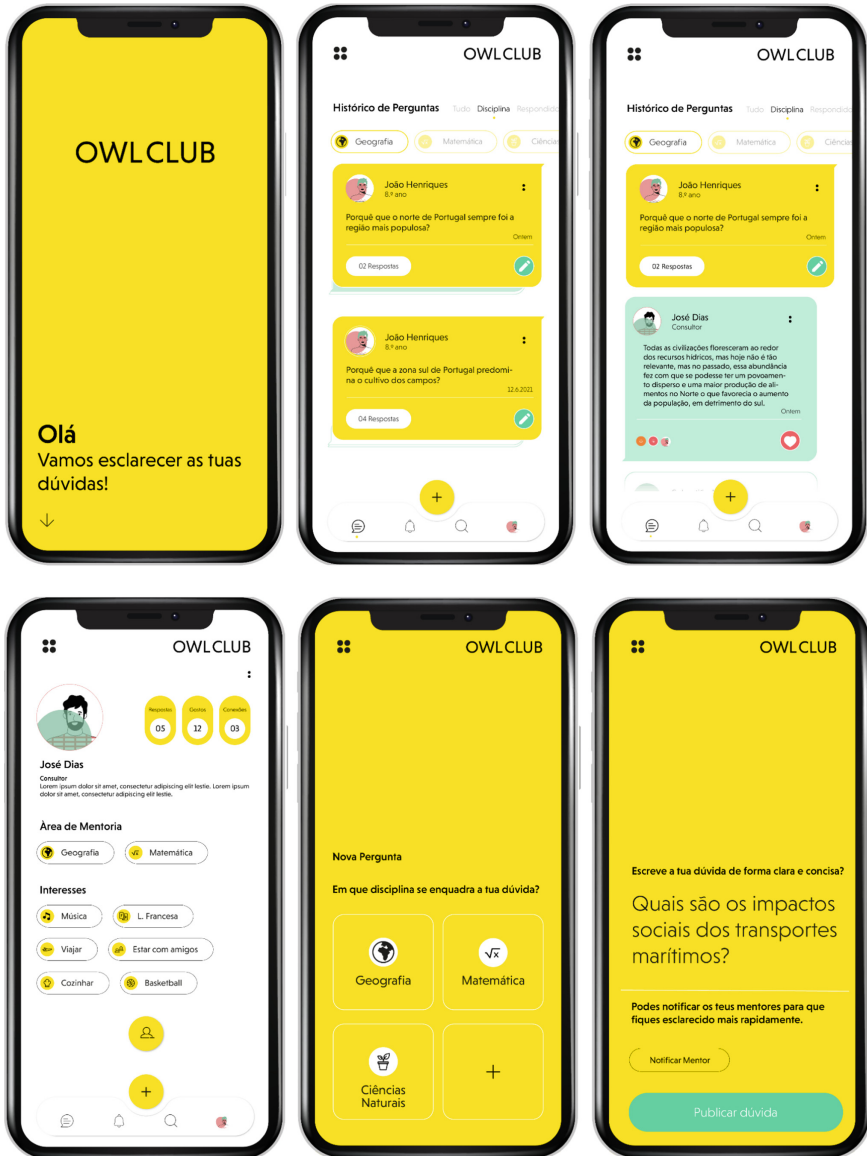
Platform\Features	Math coach	Homework coach	ICouldBe
Subscription	No	No	Yes
Costs	Free	Free	Free
Profiles displayed	No	No	Yes
Type of dyad	One-on-one	One-on-one	Group
Randomly paired	Yes	Yes	No
Duration of dyad	Instantaneous	Instantaneous	School year
Discussion prompts	No	No	Yes
Synchronous or asynchronous	Asynchronous	Asynchronous	Asynchronous
Type of interaction	Text-based	Text-based	Text-based
Mobile or web-based technology	Hybrid	Hybrid	Hybrid

### 4 OWLCLUB Mobile App System

We propose the OWLCLUB mobile app that would mitigate some of the above-mentioned educational inequities, such as learning loss and learning variability, by introducing the African expression ‘it takes a village to raise a child’. This mobile app system could also provide “a rich experience to all learners who are now without ‘traditional’ teachers” [41], thus tackling the students’ learning impairments aided by a community-centred manner “through acts of good-will and other pro-social behaviours, all while serving to connect people with others in their local community on a positive level” [40].

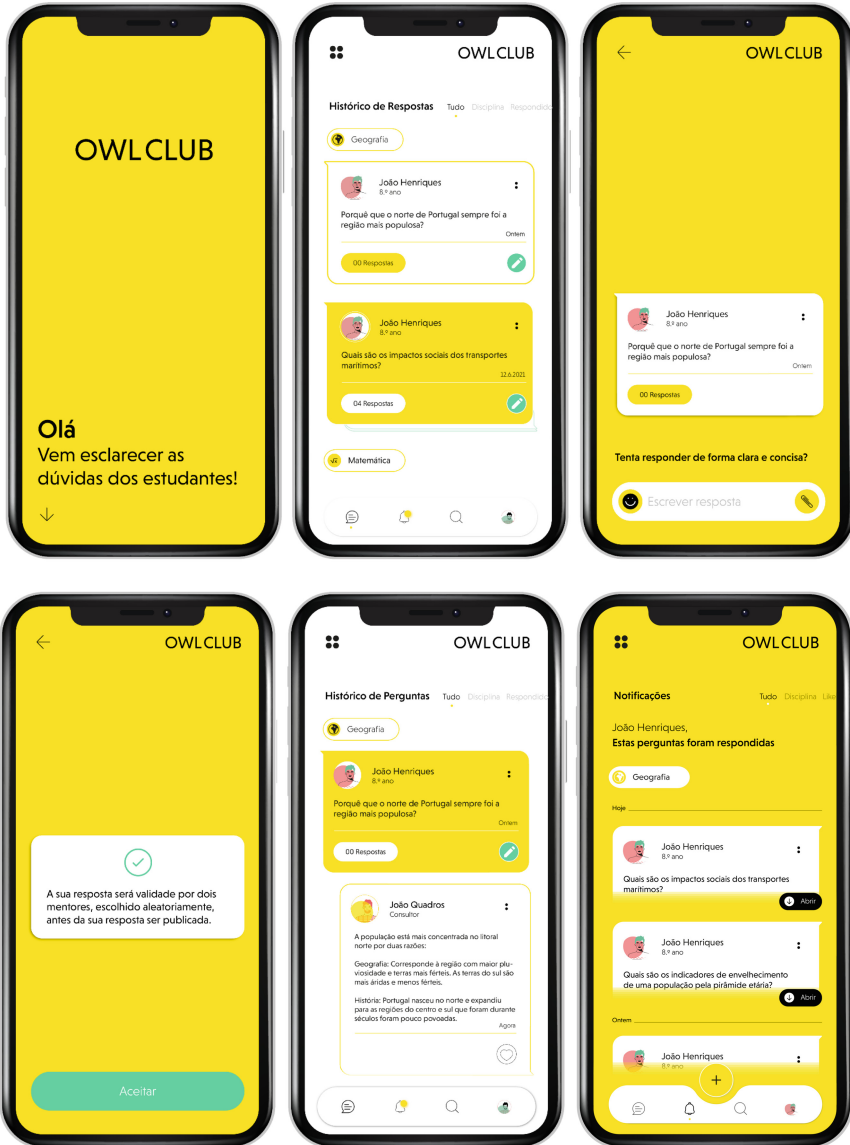
The OWL CLUB mobile application seeks to intermediate two types of users – mentees and mentors and is divided into three parts:

- a) **Sign-in and/or Registration** – where the user chooses the participant mode, select the school year they are enrolled in (student) or interested in aiding (mentor), subjects to be assisted and favourite ones (student) or to assist (mentor). Both types of users (student and mentor) select their personal interests.
- b) **Student mode** – participants interact in written format; students have access to both answered (yellow background) and not answered questions (white background) on their home screen. To publish a question, the student presses the plus button on the screen and selects the subject, followed by the question. Next, the pupil may publish or notify their favoured mentors’ network first and then publish. All users may like one of the answers that they believe is good, thus raising it to the top. The student could add a specific mentor(s), whose answer was particularly enlightening to their mentor network, thus creating a preferred communication channel between the two. See OWL CLUB mobile application system’s student mode examples in Fig. 1.
- c) **Mentor mode** – the questions answered (yellow background) and not answered (white background) can be found on the home screen, and the mentor can answer



**Fig. 1.** OWL CLUB's high-definition prototype – Mentee mode. From left to right: Welcome screen; Home screen a; Home screen b; Mentor's profile; Posing a question; Publish a question.

the student's doubts by checking the forum or the notifications. The answered doubt is accessible to the student after two randomly chosen mentors validate the provided answer to contribute with the most accurate knowledge. The mentor can like another mentor's response instead of answering it, thus raising it to the top. See OWL CLUB mobile application system's mentor mode examples in Fig. 2.



**Fig. 2.** OWL CLUB’s high-definition prototype – Mentor mode. From left to right: Welcome screen; Home screen; Answering screen; Answer’s validation; Answered question; Notification screen.

## 5 Selection and Participation of Children and Adults

This study focused on the 8th grade through convenience and purposive sampling [42], while the mentors’ recruitment had fewer constraints. The participants were divided into

two groups of ten users for both tests – five students and five mentors each test ( $N = 20$ ). The evaluation was thoroughly documented with signed informed consent (students and mentors), consisting of the study's brief explanation of what was expected from them (four tasks using the prototype and then filling out a questionnaire). Considerations about their anonymity throughout the project (by attributing a number to students (1 to 10) and mentors (11–20)) and deletion of their data upon completion of the study were emphasized. It was made aware that the participants could voice any concern or doubt during the research and withdraw their participation at any moment. For the student's safety, the individual usability tests were conducted in the school facilities, with their teacher and colleagues in the next classroom.

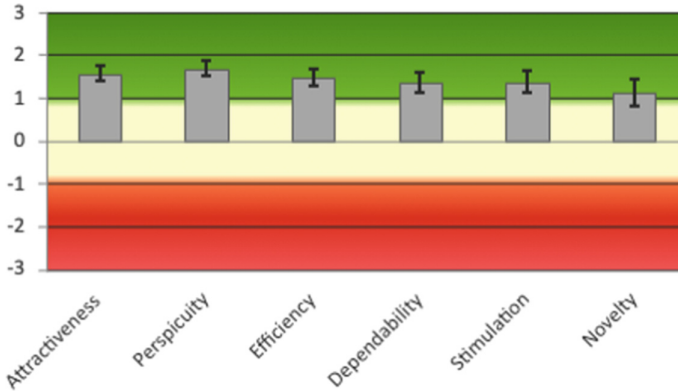
## 6 Evaluation

All participants were asked to complete four predetermined tasks using the think-aloud method [43], while an observer took notes. The tasks were: a) pose a question (student) or write an answer (mentor); b) Like one of the previously written answers; c) check the Liked answer's user profile and add them to your mentor network (student) or check student's profile (mentor); d) check notifications.

According to the analysis conducted from the questionnaires and researchers' notes, the users' initial reactions towards the OWL CLUB mobile app were very positive; they believe it is fascinating and timely (U6), especially for those needing further clarification on several subjects with various people helping them (U11, U14). For U13, it is an excellent idea because "I saw my younger sister struggling, and she often said that her teachers were not available." In addition, U11, U13 and U14 believe this idea is essential for students with more difficulties in a specific subject or content, so "it would be interesting to implement it (U14). Additionally, this mobile app is pertinent because the "students are able to pose questions in different subjects with different people helping" (U11). The education's communal assistance to students in need is also praised by U13, U14, U15 and U20. Therefore, the goal of addressing the students' learning variabilities in a community-centred manner while creating bonds in the learning process was clearly acknowledged by 80% of the users. That is, the users understood the system's aim of creating and maintaining a close learning network.

Data also indicates participants had a generally positive experience regarding the app's use on all analyzed parameters such as the attractiveness, perspicuity or clarity, dependability, stimulation, and novelty. The attractiveness and the pragmatic perspicuity, efficiency, and dependability inform that the users had a clearly affirmative response to the performed tasks. Worth noticing is that the hedonic qualities (stimulation and originality), referring to the users' thoughts and feelings while using the app, are positive and constructive (Fig. 3).

The participants were satisfied with the app's architecture and interaction, especially the "ease of finding correct answers, support and understanding the answers" (U18). The interactions between students and mentors' intuitiveness are also exalted by most users, where this will necessarily lead to "good communication" (U18) among the OWL CLUB app's users (U11, U12, U13, U14, U15, U19). A general appreciation for all interface elements was observed and all users made notice to the "very appealing colours,



**Fig. 3.** High-definition prototype usability results – Pragmatic and Hedonic app’s qualities

especially for the youngsters” (U11, U13, U14, U16, U17, U20), therefore, highly “appropriate to the app’s demographics, without being too childish” (U11). The simplicity of the interface design emphasizes the app’s straightforward usability, leading to intuitive use (U11, U12, U13, U14, U15, U16, U17).

The user’s suggestions for improvements were scarcer on the second usability test, which attests to the general progress of the high-definition prototype. The users’ main concerns were directed towards the student/mentor’s interactions and the student’s security (U1, U3, U4, U5, which was alleviated after knowing that the app would use avatars and not photos and two randomly chosen mentors would validate all writing interactions. U12 believes the system should provide more details on the answering feature, like if the other participant already opened it. Still, this claim is refuted by the remaining mentor users, because they believe the app should retain its simplicity in all aspects and have less pressure or impositions on both groups of users (students or mentors).

## 7 Conclusion and Limitations

The examined quantitative and qualitative data uncovered the stakeholders’ daily educational needs associated with new interactive digital mediums; we recognized the necessity for a flexible system to tackle the students’ distinct requirements. A pertinent design will aim to encourage and promote a system that would answer the pupil’s pedagogical needs and nurture the creation of a learning-enabling community. This system’s purpose is not to replace or subtract the school or the teacher figure from the student’s learning process but to add another element to mitigate learning loss and learning variability among students. Students could now be assisted by their teaching community, who would monitor the knowledge passed on to them; thus, avoiding decontextualized, wrong, or partially incorrect information that students acquire through search engines or their friends. Moreover, this study’s results reinstate the concept that it ‘takes a village to educate or raise a child’, an idea that impacts a shared conception of the education often bound to students and teachers and the classroom’s physical space.

Preliminary results on the OWL CLUB's mobile app seem to be validated by the tested students and mentors alike. The analysis of three hybrid e-mentoring systems proved insightful and guided the system's concept and design. The tested users praised the focus on a mobile system, heavily based on asynchronous text-based interactions, for the students' security and the openness to a broader mentor network instead of relying solely on one mentor. Regardless of the app's initial development, they saw the pertinence of its use for the school community and its applicability on a larger scale to those students without resources to belong to this interactive learning community.

Although the system has the potential to create a teaching community that could provide a specific learning experience to the students, a more profound and long-term evaluation must be conducted to assess and support our hypothesis' efficacy. Moreover, the system's full development would be necessary and tested by a more significant number of participants to get further insights into the users' interactions with the app and how fruitful the exchanges among this community would be to the student's academic growth.

This study tried to extend the scope of research by looking for a wider variety of participants. Yet, the COVID-19 pandemic's constraints did not allow to accommodate more individuals in the longitudinal mixed-method study. The anecdotal sample's limitation is acknowledged, and some findings could be seen as tentative interpretations. Additionally, the digital divide and its role in the lack of learning opportunities for the most disadvantaged students are acknowledged and not fully addressed in this study.

## 8 Future Work

In order to grant a more comprehensive and augmented understanding of this matter, future work may encompass more individuals and more extensive groups of stakeholders of diverse ages, educational, geographic, and cultural backgrounds. It would also be beneficial to analyze these subjects' perceptions and experiences of a fully developed system in the long term and how such examination relates to this study. The long-term analysis could examine the impact of the learning environment and the personalized teaching mediated by this system on the student's academic achievements, namely their evolution in the subject(s) they had more difficulties with.

Future work could also evaluate solutions that could grant the users' participation continuity, like implementing gamification components that reward the users' interactions and the accuracy of responses on the mentor's behalf.

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