Transforming Science Education at Grade 9 With a Pedagogical Technological Integrated Medium: An Integrated Approach for Teaching, Learning, and Assessment

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Abstract
The study aimed to explore the potential of technology beyond its role as a teaching tool in science education by introducing the concept of a Pedagogical Technological Integrated Medium (PTIM). The PTIM approach functions as a platform for scaffolding, enabling students to construct meaningful knowledge structures. It brings together teachers (T), learners (L), and parents (P) in a TPL nexus to facilitate learning and promote the development of positive attitudes through interaction with peers, teachers, and parents. The PTIM philosophy was integrated with a set of science lessons for Grade 9 students (14 years old), covering biology, chemistry, and physics, on the educational platform "myptim" (https://myptim.org).This platform offers a range of valuable features, including testing of prior knowledge, parental interactions, cognitive engagement, and immediate feedback through diagnostic and formative assessments. The study used a qualitative approach for data collection and analysis. Data were collected from a science teacher, learners, and parents through questionnaires and interviews. Results showed that engagement of learners is sustained both at home and in schools through carefully crafted activities. In addition, the TPL nexus was found to be beneficial, allowing for two-way messaging between teachers and parents, identification of weaknesses in learners' prior knowledge, and monitoring of learners' progression and engagement. Overall, the study has far-reaching significance for improving teaching and learning of science at the Grade 9 level. It highlights the need for further exploration of the potential of technology in education, with a focus on its role in facilitating learners' construction of knowledge structures.

Keywords: Technology Integration, Teaching, Learning, Assessment, Teacher-Parent-Learner Nexus

Introduction

Technology has deeply embedded itself into every corner of our contemporary society, with the education sector being no exception. Driven by educators' motivation to resonate with the contemporary generation of learners, often referred to as "digital natives" (Dingli & Seychell, 2015), modern pedagogical methods harness the expansive capabilities of advanced technological tools.

The landscape of educational technology spans a broad range of devices and software applications. These tools, celebrated as catalysts for a transformative societal structure (Rutkauskiene et al., 2012), offer real-time access to a world of information. Their flexibility provides unparalleled opportunities for global, synchronous communication, marking a transformative moment in educational evolution (Kraglund-Gauthier, 2015).

While the integration of such technology into education has unlocked new avenues for learning, it also brings forth questions surrounding student engagement and interactions within these digital spaces (Bharati, Fors, & Tedre, 2017; Cocieru, Katz, & McDonald, 2020). Classic, learner-centric classrooms emphasize active knowledge construction within collaborative ecosystems. However, the efficacy of a technology-driven educational space is contingent on the caliber of instructional strategies adopted. It is imperative to understand that the mere incorporation of technology does not assure improved learning outcomes; it must be synergized with effective instructional methodologies (Dynarski et al., 2007; Kulik, 2003).

In a conventional learner-centered classroom where technology is absent, the teacher adopts learner-centered strategies to drive classroom interactions which are needed for successful deep learning endeavours. Students are engaged in minds-on and hands-on tasks and are made to operate in groups to construct knowledge in a spirit of co-operation in this specific kind of setting, while the teacher adopts quintessentially and by default the role of a facilitator in challenging learners towards the fulfilment of desired learning goals. On the flip side, namely in a technology-mediated environment, Ross *et al.* (2010, p. 19) posit that effectiveness of technology "depends on how well it helps teachers and students achieve the desired instructional goals" and, regardless of the form of instruction adopted (e.g., lecture or computer-assisted), it "could be effective or ineffective based on the quality of the instructional strategies employed".

In a technology-driven (virtual) learning environment, students do not automatically develop conceptual understanding of the content (Flanagan & Shoffner, 2013; Tamim, 2011) unless technology is meaningfully incorporated into an interactive teaching-learning environment. A profound "paradigm shift" (Kuhn, 1970) in assimilating technology into pedagogical practices is indispensable. Instructors must evolve into proficient guides in these tech-savvy environments, necessitating continuous professional development and the inclusion of real-world discourse patterns in their teaching (Scardamalia & Bereiter, 1994). It's also pivotal to acknowledge that online education structures often grapple with higher attrition rates compared to conventional learning environments, underlining the critical issue of student disengagement (Rovai, 2002; Carr, 2000).

In this backdrop, a comprehensive reassessment of our strategy for technology's integration into education is vital. By strategically amalgamating technology with traditional teaching approaches, we can pave the way for a more enriched learning journey, intertwining cognitive, emotional, and social facets (Ramma, Bholoa, Watts, & Nadal, 2018). The onus is on educators to harness the full potential of modern technology within an education framework ripe for transformation (Bates, 1997).

The Case of Mauritius

Mauritius is eagerly moving towards adopting a full-scale technology-enhanced learning system, striving to align with the latest, state-of-the-art educational models and trends endorsed and embraced by countries globally. With a population of roughly 1.3 million, Mauritius boasted an internet and social media penetration rate of 68% in January 2020 (Kemp, 2020), and the number of digital connections was correspondingly significant, reaching 15% of the total population. Mauritian students frequently utilize advanced technologies in their daily activities, prompting sustained initiatives by local educational authorities to integrate these technologies into learning. In 2014, tablets were distributed to Grade 10 (age 14) students. Presently, students in Grades 1 to 3 utilize tablets during lessons, while the prospect of introducing tablets to pre-primary schools is being discussed.

Recent research conducted in the Mauritian context (Hurreeram & Bahadur, 2019; Jugee & Santally, 2016; Ramkalawon & Bholoa, 2016) suggests that Tablet PCs are viewed as promising tools for technology-mediated pedagogy. Notably, interactions between teachers and students and among students have markedly benefited from this integration. However, a substantial dependence on traditional teacher-learner interaction persists in the learning process. This dynamic impedes the full realization of technology's potential in classrooms, especially as many educators seem to lack confidence and expertise in integrating Tablet PCs (Bholoa, Ramkalawon, & Purdasseea, 2015), often leading to a technological divide between instructors and pupils. A significant number of teachers have voiced the need for comprehensive training and continuous professional development (CPD) regarding this. Current training workshops for educators have been deemed "basic and hence... not aligned with the demands of a genuine classroom setting" in a study by Hurreeram and Bahadur (2019, p. 28). The primary teacher training institution in Mauritius still needs to offer dedicated CPD on integrating technology in classrooms. The institution urgently needs to investigate the potential of delivering micro-credential CPD on technology utilization to educators.

Objectives of the Study

The broader aim of the research study is to design and develop the Pedagogical Technological Integrated Medium (PTIM) as a comprehensive platform that facilitates interactive technology-based lessons tailored for teachers, students, and parents. This paper elucidates the functionalities and features of the PTIM website (http://myptim.org) as a dynamic medium that champions interactions within the teacher-parent-learner (TPL) nexus. An integral aspect of this work is to report on the effectiveness of the PTIM platform in nurturing an interactive setting, thereby enhancing the enactment of the TPL nexus. The potential of myptim.org in providing a conducive environment for teaching support and amplifying the learning experiences for teachers, parents, and learners respectively is also assessed. By evaluating the transformative impact of the PTIM platform on teacher preparedness, parental involvement, and learner engagement, the study delves deeper into understanding its efficacy in an integrated teaching and learning milieu. Lastly, we report potential challenges and barriers encountered by users of the PTIM platform and we propose pragmatic solutions ensuring a seamless and efficacious TPL interaction.

The PTIM Model

In this part of the paper, we elaborate on the Pedagogical Technological Integrated Medium (PTIM) model that draws from the Technological Pedagogical Content Knowledge (TPACK) (Mishra & Koehler, 2006; Mishra & Koehler, 2007) and Community of Inquiry (COI) (Garrison & Vaughan, 2008) frameworks in particular. Like TPACK, our proposed model draws from Shulman's (1986) conception of teachers' content knowledge, pedagogical content knowledge and curricular knowledge. However, our model embraces broader considerations and Figure 1 throws light on our perspective regarding the relationships between content/contextual knowledge, technology, pedagogy, the affective domain and social dimensions.

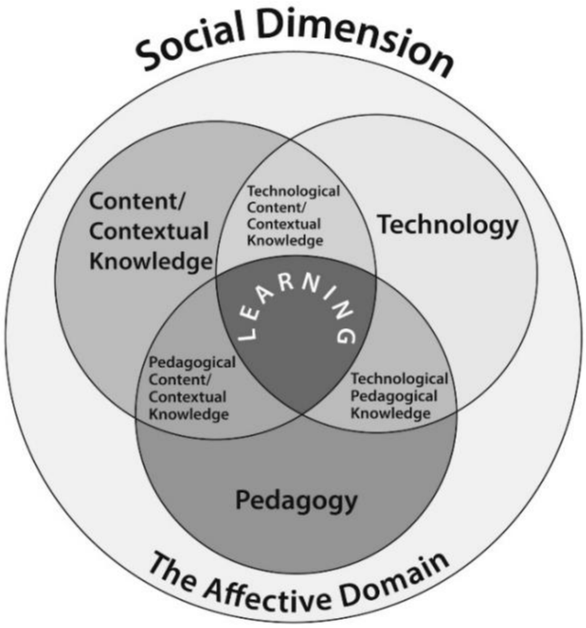

Figure 1: Pedagogical Technological Integrated Medium (PTIM) model

The PTIM model stipulates that the subject matter should always be contextualised, that is, set within a specific context (de Figueiredo, 2005). We opine that disembodied knowledge generates fragmented and effortlessly dissipated and unproductive learning. Context, on the other hand, acts as a reservoir of prior knowledge enabling the learner to relate with the newly acquired knowledge through a process of memory reactivation (van Kesteren, Krabbendam, & Meeter, 2018). The technology component of the model orients towards learners' increased use of devices such as laptops, tablets and smartphones to support learning. Technology should not be the means to deliver the content (de Figueiredo, 2005) rather construed and utilised as a medium that empowers learners in the construction of purposeful and meaningful knowledge structures. Pedagogy forms the third core element of the PTIM model.

Our interest here is in three essential constituents of pedagogy. Firstly, teachers are expected to be well-acquainted with technology-driven pedagogy in their professional realm. Teachers are tasked with elucidating and executing this technologically centric pedagogy to fully elucidate both the overarching and nuanced implications of the philosophy 'leading learners to learning' through the application of technology. They are also expected to act as facilitators, paving the way for a smooth integration of technology-driven learning in the classroom. It's pivotal for teachers to embark on professional development courses to amplify their technical proficiencies and to inspire a transition to teaching methods anchored in technology. During these professional enhancement courses, educators will be equipped with the capabilities to foster collaborative technology-based learning environments and team-teaching methodologies (see Figure 2).

Furthermore, the significant role and contribution of parents in the educational journey of learners should be appropriately acknowledged and given its due importance, as a substantial amount of learning occurs within the family context. Our previous work (Ramma, Bholoa, Watts, & Nadal, 2018) delved into and illuminated the extent of these interactions within the teacher-student-parent nexus. Technology acts as a formidable conduit to enhance the interactions between teachers and students. With meticulously curated lessons, it holds the capability to facilitate the sharing and connection of experiences (based on prior knowledge), offer real-time feedback, and forge effective communication and relationships, thereby nurturing ultimate student progress and achievement. Additionally, students can utilize various technological devices and potent educational tools for independent learning and for interacting and collaborating with their peers.

The PTIM model strongly advocates and underscores the significance of the affective domain in the learning process within a multidisciplinary approach (Figure 2). In this specific study, we are interested in the ways in which these three elements – content/contextual knowledge, technology and pedagogy impact upon the lived experiences of teachers and learners. This includes their feelings, attitudes, and motivations towards evolving their methods in technology-enhanced learning.

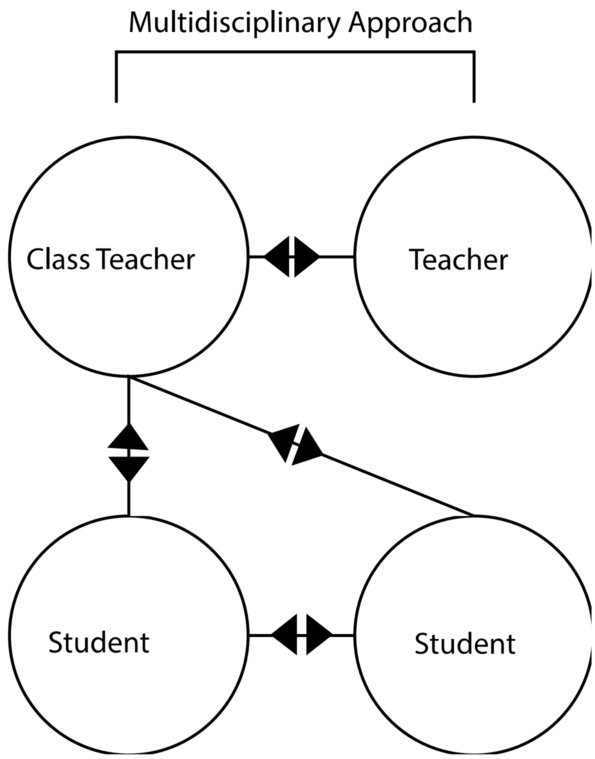

Figure 2: Teacher-student interactions

The engagement of students in the presence of the teacher makes a marked difference in the learning process. Bholoa et al. (2020, p. 116) opine that "increasing reliance on technology and digital tools can negatively affect our social skills, moral values and ethical principles". In an online environment, students feel disengaged as they are not in the physical presence of a teacher (Kennette & Redd, 2015) who is responsible for engaging learners in critical discourse situations. Brown and Duguid (2000) further affirm that, even with the advent of novel technologies, the interaction level among learners should remain at the cynosure owing to the fact that the social context dictates measurably the development of technology rather than the other way round.

Figure 3 and Figure 4 show two interactive web-based lessons (Ramma, Bholoa, Watts, & Nadal, 2018) which can be accessed through both Android and Apple mobile devices, thereby allowing flexibility of lesson delivery (https://myptim.org).

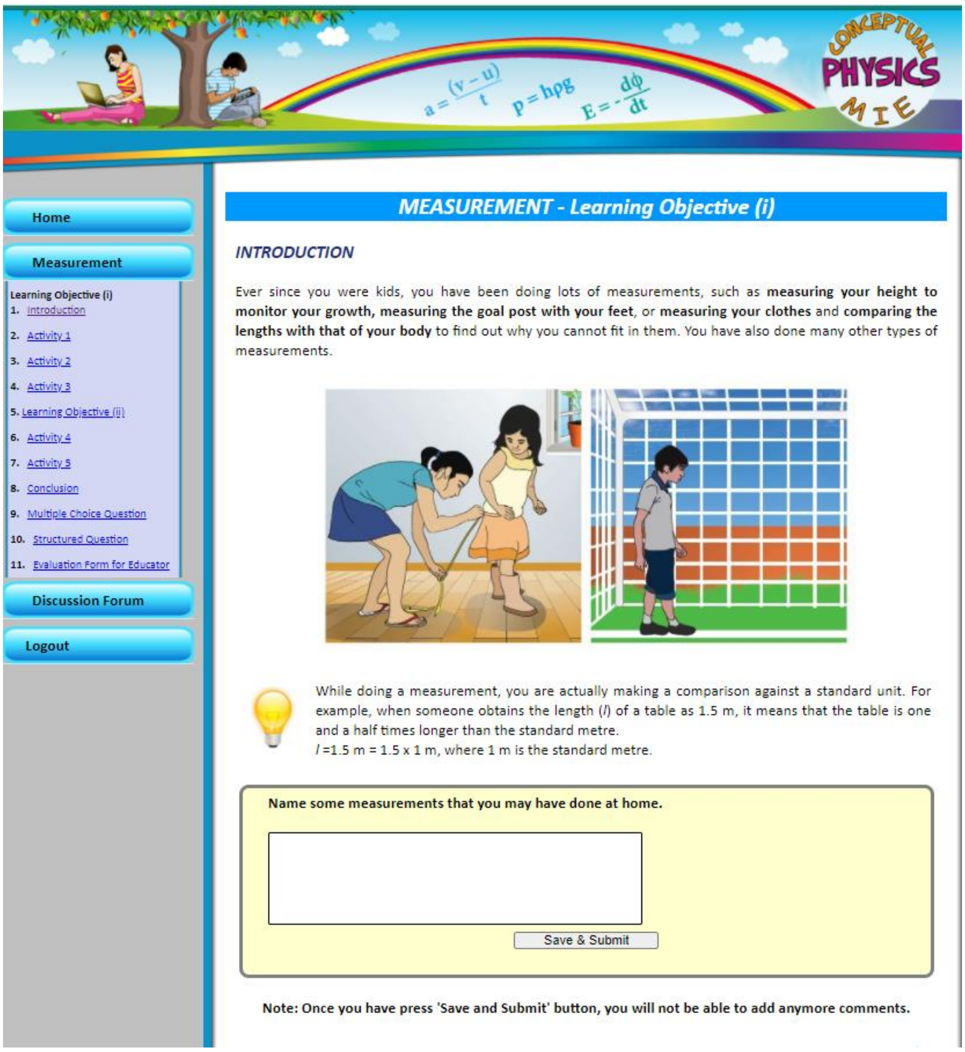

Figure 3: Interactive web-based lessons on ‘Measurements’

Both lessons contain a set of diagnostic, formative and summative assessment tasks which provide multiple perspectives to the learners, thereby allowing them to deepen their understanding of the concepts under study. In addition, some diagnostic tasks are meant to be conducted at home with the support of the parents, and these serve to review prior knowledge in a flipped classroom type approach. Upon the completion of tasks, the students upload their answers, the teacher examines the answers and then discusses them in the classroom setting.

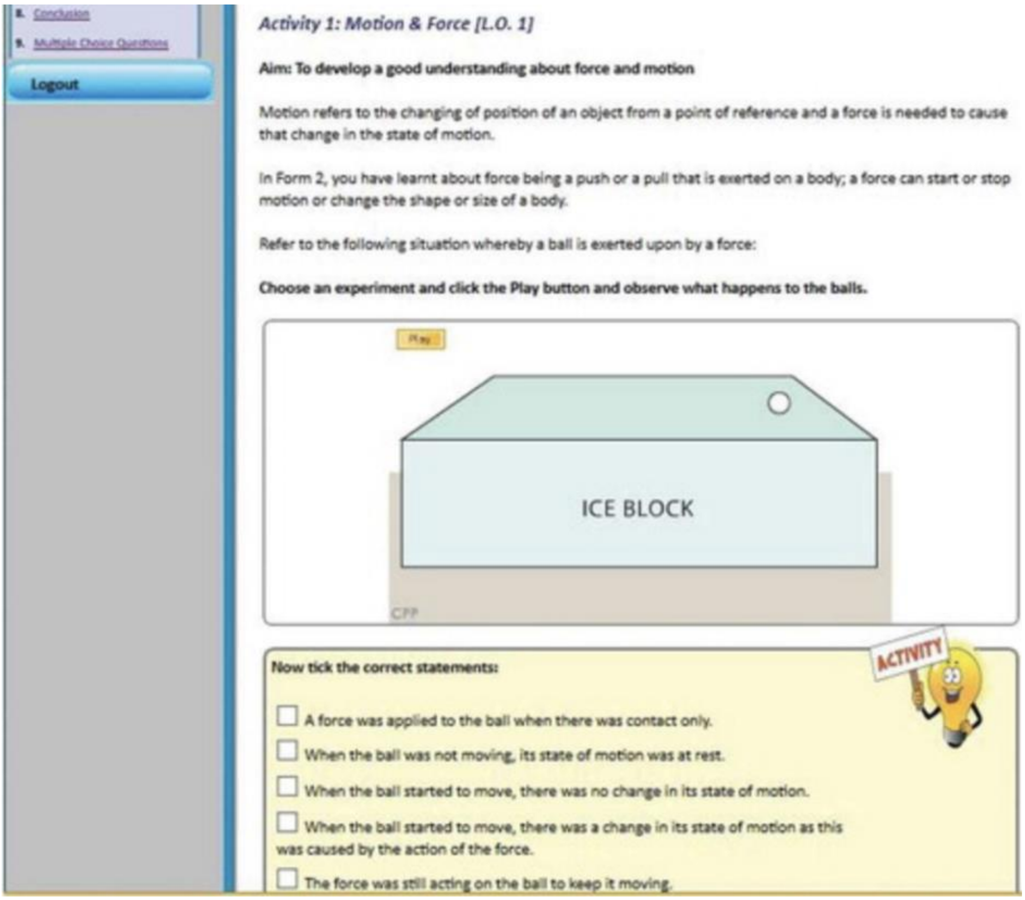

Figure 4: Interactive web-based lessons on ‘Motion’

Methodology and Participants

In a bid to understand the intersection of technology and education in the context of Mauritius, a qualitative research methodology was deployed. This methodology, deeply rooted in semi-structured interviews, was designed to yield detailed insights into the lived experiences of educators, students, and parents as they navigate the landscape of technology-mediated education. By leveraging both deductive and inductive analytical approaches, the research sought to explore existing knowledge and identify emergent themes in the data. Each interview was thoughtfully designed, comprising five primary questions bolstered by subsequent probes to delve deeper into the participant's perspectives. While the phone-based interviews were concise, typically lasting between 10 to 15 minutes, they were rich in content. These conversations were meticulously audio-taped, transcribed, and subsequently analyzed.

The research unfolded in two distinct phases. The initial Design and Development Phase saw the active participation of 15 science teachers drawn from three secondary schools in Mauritius. The diverse group, consisting of educators specializing in biology, chemistry, and physics, collaborated on the design and development of Grade 9 science lessons. Their insights and feedback, primarily collected through questionnaires during workshops, proved invaluable. As the research transitioned to the Implementation Phase, it honed its focus on a micro-level, centering on one school. This phase was characterized by interactions with a single teacher and her Grade 9 class comprising 22 students. In-depth interviews were conducted with this teacher, along with a selection of 5 parents and 6 students to ensure a holistic understanding of the platform's impact.

Conclusions

Findings: A Triangular Perspective

Feedback from different stakeholders offered a comprehensive view of the platform's efficacy.

Students emerged as keen observers of the platform's functionality. Their collective feedback resoundingly affirmed the platform's user-friendliness, accessibility, and utility. The immediacy with which the platform addressed their questions was a standout feature for them. However, a constructive critique arose from their collective desire for the integration of structured questions, akin to those they encounter in their physics textbooks and examinations. This revealed an inherent need for familiar structures even in novel learning environments.

Parents, on the other hand, viewed the platform as a bridge to their children's educational journey, a sentiment reminiscent of their involvement during the primary education years. The platform's design, which allowed easy comprehension and round-the-clock access to teacher instructions, was lauded. In an interesting revelation, a parent voiced how the platform doubled as a learning tool for her, underscoring the potential of such technologies to transcend traditional learner demographics.

The teacher's feedback was a blend of appreciation and revelation. Accustomed to the conventional reliance on textbooks, the platform offered her a fresh vantage point. It became evident that while she hadn't been maintaining ongoing records of individual student progress, the platform flagged misconceptions and knowledge gaps in real-time. One such example was the students' misunderstanding related to the SI unit of volume. Empowered by these insights, she could proactively address misconceptions, optimizing her classroom teaching. This proactive approach contrasted with her erstwhile reactive stance, which typically revolved around post-test or examination interventions. Additionally, she acknowledged a foundational familiarity with crafting online content, hinting at the latent potential that can be harnessed with adequate training.

Implications, Recommendations, and the Road Ahead

The findings shed light on several implications and pathways for enhancing technology-mediated education. One of the immediate takeaways was the need to integrate structured questions into the platform. Students' unanimous feedback highlighted the comfort and value they associate with familiar structures, suggesting that blending novelty with familiarity could optimize engagement and learning outcomes.

The platform's potential as a diagnostic tool was evident. By spotlighting misconceptions or gaps in understanding in real-time, it offered educators a proactive tool to tailor their teaching strategies, thereby enhancing learning outcomes. Coupled with this was the realization of the platform as an avenue for parental engagement. The feedback from parents suggested that such platforms could rekindle their active involvement in their children's educational journey, much like the primary years.

However, for these potentials to be fully realized, the onus is on equipping educators with the necessary skills. The teacher's feedback highlighted a latent familiarity with online content development. By investing in targeted training programs, this latent potential can be transformed into active prowess, ensuring that educators are not just consumers but creators in technology-rich educational environments.

As for the future, the research team is poised for further enhancements. The immediate plan involves augmenting the platform with open-ended questions, buttressed by real-time feedback mechanisms. The grand vision, contingent on funding, is to metamorphose the platform into a full-fledged Teaching-Learning Management System (TLMS). Parallelly, there's an ongoing effort to craft a standalone module, tailor-made to bolster the skill sets of teachers. This module is envisioned as an integral component of their Post Graduate certificate in Education (PGCE) course, ensuring that the next generation of educators is adept at navigating and optimizing the potentials of technology in education.

Limitations

We recognize some limitations in our methodology, particularly the absence of a separate pre- and post-test assessment and a control group. These elements could have bolstered the empirical robustness of our findings. However, the study's primary intent was to delve into firsthand experiences and perceptions of platform users rather than a comparative efficacy analysis. The approach, while more exploratory, enabled a rich, qualitative understanding of the platform's impact, laying groundwork for future, more structured studies. Additionally, while we leaned on parental oversight to ensure compliance outside school, we acknowledge the potential variability this might introduce. However, our aim was to simulate a realistic home environment, capturing authentic interactions with the platform. The participation of parents was predominantly passive. They were integral in facilitating and overseeing their child’s interaction with the platform, given the secondary school level of the participants. Their feedback about the platform was also actively solicited to gather a more holistic perspective.

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