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Editorial / Éditorial Volume 50 Issue 2

***Martha Cleveland-Innes**, Editor-in-Chief*

Welcome to Volume 50, Issue 2, of the *Canadian Journal of Learning and Technology* (CJLT). CJLT is a decades-old peer-reviewed journal that invites English or French submissions on the research and practice of education, technology, and learning. This bilingual journal is free-of-charge to anyone with access to the Internet, is multi-indexed, and is presented in accessible formats. There are no article submission/publication fees or access charges.

The Editorial team completed and released this issue as the calendar changed to 2025. CJLT's scope covers all things relevant to education and technology use. The current state of Canadian and global education includes demands for change in response to social and economic challenges. According to a well-known GenAI program, the two biggest issues facing education in Canada are accessibility and quality. More distressing is that the Education in Canada Current Issues Report of May 1994 identifies those same two issues as education's most critical. Despite significant contextual changes, and those in technology and education design, these two things continue to plague us. CJLT provides research addressing this changing education context, the same issues of accessibility and quality, and emerging education theories and practices.

A *Book Review* of *Online by Choice: Design Options for Flexible K-12 Learning* by Stephanie Moore and Michael Barbour is presented by Tim Dolighan of the *Ontario Tech University, Canada.* This excellent volume provides information on two essential areas of design for K-12 blended and online learning. Moore and Barbour draw from sound and practical research-based strategies for K-12 learners to distinguish between emergency remote online learning during the Covid-19 pandemic and appropriately designed online and blended delivery for diverse learners. In addition, they propose that successful online implementation requires collaboration between school administration and classroom teachers. Tim Dolighan identifies the book's usefulness for educators wishing to develop online teaching skills and suggests professional development opportunities in his review.

Each CJLT issue's Notes Section offers a space for applicable reports and discussion of germane current issues. The Notes Section includes non-empirical reviews of current and potential future states of the education field. This issue's Note*, Behaviourist-Constructivist Pedagogical Design Possibilities Within the Community of Inquiry Framework/Possibilités de conception pédagogique behavioriste-constructiviste dans le cadre de la communauté d'enquête,* is presented by Sheriya Sareen and Sayantan Mandal of the Indian Institute of Technology Jammu, India. Sareen and Mandal consider the issue of pedagogical design from a behaviourist-constructivist lens, in reference to the community of inquiry. The authors offer this paper to spark discussion about the "impact of missing out on behaviourist designs on the CoI framework through the problem of epistemological untenability and that of assumed learning." CJLT invites future discussion and empirical study that considers both the theoretical foundations and practical implementation of the community of inquiry framework, across disciplines and cultures.

Four peer-reviewed research articles make up the remainder of this issue. True to the current context, robot use in K-12 education is studied in the first two articles. The line between AI and robotics is still blurred, as we determine where one begins and ends, and what constitutes the overlap. Higher education and technology implementation links the other two articles. One informs university teachers about technology and formative assessment while the other evaluates a study-tracking application and the impact on student procrastination.

Article one, *Formation initiale des enseignants : explorer le potentiel d'un robot de téléprésence/Preservice Teacher Training: Exploring the Potential of a Telepresence Robot*, was created by a team of researchers from the Université de Moncton, Canada: Marc Basque, Xavier Robichaud, Robert Levesque, Lyne Chantal Boudreau, Mathieu Lang, and Viktor Freiman. According to Merriam-Webster, a telepresence robot is the label given to "technology that enables a person to perform actions in a distant or virtual location as if physically present." According to Basque et al., teacher training experiences in the field were unavailable during the Covid-19 pandemic. As one remedy, 17 preservice teachers were able to practice teaching in local schools using a telepresence robot. The findings indicate that the preservice teachers could interact with the students and acquire pedagogical knowledge related to teaching. The reviewers and the CJLT Editorial team believe this kind of study contributes to our continuing quest for enhanced education quality through teacher training innovation and access to highly qualified teachers.

The *Effects of Robotic Coding on Computational Thinking Skills of Secondary School Students/ Effets du codage robotique sur les capacités de réflexion informatique des élèves de l'enseignement secondaire* is written by Serhat Altıok and Memet Üçgül of Kırıkkale University, Turkey. Robotic coding activities refer to a much different set of learning activities and a much different type of equipment – but still fall under the lexicon of robotics in education. Altıok and Üçgül suggest that robotic coding activities among secondary school students could impact the self-efficacy needed for computational thinking skills. Lego Mindstorms EV3 Education Robots supported a total of 20 hours of coding. Serhat Altıok and Memet Üçgül used a quasi-experimental design and quantitative statistical analysis which identified "a significant increase in students' self-efficacy perceptions of computational thinking skills." This important research report includes directions for replication and further research.

Technology applications continue to support higher education student performance and instructional activities. Maya Murad and K.C. Collins of Carleton University in Canada are scholars of Information Technology. *StudyTracker Self-Tracking App and its Relationship to University Student Procrastination/L'application d'autosuivi StudyTracker et sa relation avec la procrastination des personnes étudiantes universitaires* is a quasi-experimental appraisal of procrastination and study habit tracking. A self-tracking digital app, created by the authors, provided feedback to the students in the form of text and charts. Maya Murad and K.C. Collins outline student interpretation of study tracking feedback and its impact on procrastination habits across the experimental and control groups.

A technology application in support of a different kind of feedback is the subject of the fourth article, *Technological Tool for Formative Assessment in Higher Education: ZipGrade/Outil technologique pour l'évaluation formative dans l'enseignement supérieur : ZipGrade*. Authors Bani Arora and Abdulghani Al-Hattami, University of Bahrain, offer descriptive results based the digital assessment tool, ZipGrade. Undergraduate education students are offered immediate formative feedback on quiz responses. Students describe their reports as positive based on ease of use, immediate feedback, and increased engagement. Bani Arora and Abdulghani Al-Hattami outline the benefits and challenges of this student assessment tool, suggest ways to overcome barriers, and give directions for future research.

We invite you to continue to support CJLT by submitting articles, providing reviews, and citing the research we rigorously evaluate and carefully publish. We continue to focus on education technology trends and beyond, to ensure that quality and accessibility continue to get space in CJLT. The UNESCO International Day of Education 2025 meeting is focused on "Artificial Intelligence and Education: Challenges and Opportunities." It will take place in New York this month. Along with the many predictions for education change in 2025, this UNESCO meeting will examine new and enduring AI applications along with the human experience of teaching and learning. These topics align well with CJLT's focus on the research and practice of education, technology, and learning.

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Online by Choice: Design Options for Flexible K-12 Learning. (2023).

Reviewed by ***Tim Dolighan****, Ontario Tech University, Canada*

Abstract

Online by Choice: Design Options for Flexible K-12 Learning by Stephanie Moore and Michael Barbour offers a comprehensive exploration of building a resilient educational ecosystem through blended and online learning options. This review highlights the authors' adept construction of practical, research-based strategies for K-12 communities. By distinguishing between emergency remote learning and purposefully designed online education, Moore and Barbour guide educators in identifying and addressing diverse learner needs in the context of designing and implementing online and blended learning. The authors stress the collaborative effort required between system administrators and teachers for successful online implementation. This review explores the book's utility for educators seeking to enhance their online teaching skills and suggests avenues for future professional learning development in online contexts. Ultimately, *Online by Choice* emerges as a vital resource for designing effective online learning experiences tailored to the evolving needs of K-12 learners.

Keywords: blended learning, K–12 learning, online design, online learning

Introduction

Stephanie Moore and Michael Barbour have expertly constructed a practical research-based guide on how to build a flexible educational ecosystem that utilizes blended and online learning options. The authors provide practical planning steps and research-based online teaching and learning strategies to support and guide K-12 school communities looking to meet the needs of diverse learners. Online learning got a bad rap by many K-12 educators from the challenges and experience of having to suddenly transition to online teaching and learning during the COVID-19 pandemic. The authors make the clear distinction between emergency remote learning and purposefully designed blended and online learning that fit within the larger educational ecosystem that seeks to meet the changing needs of learners. *Online by Choice* is a comprehensive and useful resource for school leaders, system planners, and educators who are committed to building a resilient educational system that includes online teaching and learning as part of a broader community seeking to meet learner needs.

The book moves the reader through identifying specific needs in the community and how to design appropriate online learning experiences that address those needs. Chapters 1–3 provides an introduction that clarifies what online and blended learning is and how it can be used successfully to meet diverse student needs. Rather than focus on the merits of online learning, the authors help the reader investigate the initial choice to offer online learning as a response to learning gaps and diverse needs. Moore and Barbour situate online learning within the context of the educational community and provide tools to help school districts identify those needs and use online learning as a solution to identify learning needs rather than presenting online learning as a solution in search of a context. Chapters 4 through 10 dive into quality online teaching based on research and practice and the final two chapters circle back to systemic supports and planning for online teaching and learning options.

The book includes useful suggestions and ideas to support the design and implementation of effective online spaces and resources to help educators meet the learning needs of their community. The authors make clear that effective planning and implementation of online spaces are a collaborative endeavour between system and school administrators in concert with teachers. Chapters 4 through 10 dig into the details of research-based quality online teaching and learning strategies to build online communities that facilitate learning and engagement online that includes system and school level planning and support. Chapter 4 covers design decisions and structure for online learning that supports student success. The authors describe effective structure and design of online learning that can facilitate self-regulation skills that includes access to social and community resources. The online design and structure advice and examples work particularly well for middle school and high school contexts that are the focus of the guidance provided by the authors. Similar guidance and expert direction would be useful for primary and junior (K–6) educators who identify learning needs that can be supported by online or blended learning. The transition to emergency online learning during the pandemic exposed unique challenges for teachers working with younger students (Dolighan, 2023)

The next chapter, Chapter 5, focuses on building community in the online context. Moore and Barbour employ the Community of Inquiry (CoI) framework (Garrison et al., 2000) and the Academic Communities of Engagement (ACE) framework (Borup et al., 2020) to create the foundation for building a vibrant community that supports students and addresses isolation. The CoI framework helps teachers frame online learning by establishing strong interaction between the teaching presence, social presence, and cognitive presence to build community. The personal community support described in the ACE framework presents an opportunity for planners to identify and integrate support necessary for academic success online. Moore and Barbour provide an example of how course community supports from an ACE plan can be used when instructional planning of technology evaluation and selection identifies the need for multiple-user creation features that support community and interaction as opposed to a one size fits all template.

Chapter 6 delves into how to foster student engagement and interaction through the lens of both the CoI and ACE frameworks. Consideration is given for planning who and what students interact with, concrete effective examples are given of how to facilitate learner interactions with content, peers, the instructor, the learning platform, and their environment as well as vicarious interactions. The next chapters, 7 and 8, move into specific instruction strategies that consider how content is best organized and presented to support engagement and learning. Practical ways to utilize both asynchronous and synchronous modalities while providing clarity for online terms that are often misused are detailed. The authors breakdown and simplify online tools like *Zoom* to better understand affordances and limitations as they apply to instruction in online contexts. Chapter 8 includes specific attention to design principles for multimedia content presentation that supports learners' ability to organize and integrate new knowledge. Teachers will find strategies specific to STEM- and arts-based learning. Moore and Barbour address challenges of how to present digital content and create effective multimedia learning experiences based on learning theory and research. An example the authors use is in content presentation using the multimedia principle developed by Mayer (2020) that learning happens better from words and pictures versus words alone. Astutely designed digital content that considers cognitive load and how much information learners can process enhances learning. With specifically designed guidance based in research, the chapter details effective practices and principles to guide the creation of digital content development and presentation.

Chapter 9 builds an assessment strategy framework that views online assessment as a strategy that supports student learning. The approach reframes online assessment as a learning strategy rather than behaviour management and provides guidance and examples of how to implement assessment tools that support learning. Moore and Barbour acknowledge that policies and practices have not kept pace with advancements in online learning and educational technologies. The increase in the collection of data used to assess students and the need for educators and administrators to consider in the design phase how data is used and collected. As technology continues to develop at a rapid pace, the challenge to understand the implications and potential of technology, grounded in learning theory and research remains.

The importance of organization and communication when preparing to implement and deliver the online learning experience is underlined in Chapter 9. The authors provide practical steps to creating a learning climate supported by tips and checklists throughout the chapter. The collaboration between systemic planning and instructional decisions informing each other is weaved throughout the book, illustrated by examples of *handshakes* that help school leaders and educators at each stage of design and implementation.

The last two chapters revisit systemic supports and planning strategies to support plan and assess performance. Moore and Barbour identify numerous opportunities for administrators and educators to work together to plan and implement online learning. Chapter 12 identifies how the two levels can collaborate and inform one another. For example, procurement of technology decisions that include multiple stakeholders can avoid wasting time and resources and valuable energy.

The examples and ideas provided by Moore and Barbour offer detailed support for teachers designing and implementing online learning experiences that are driven by community needs. This book is a tremendous resource for teachers who are new to teaching online or are seeking to develop their online teaching skills. As online teaching becomes recognized as a valuable component of a diverse educational ecosystem, specific attention could be given to designing ongoing professional learning that facilitates agency for teaching staff and meets the diverse needs of teachers who are designing and implementing the learning. It would be worth including how professional learning could be established in an online context that could access the affordances offered by online professional learning such as contextual and continuous learning within a community of practice that can be ongoing, as teachers continuously apply learning to practice in cycles of action (Morrison et al., 2021).

This book is a much-needed support for designing and implementing effective online learning experiences to meet the changing needs of K–12 learners and utilizing online learning affordances to enhance learning experiences based on identified needs in the school community.

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Behaviourist-Constructivist Pedagogical Design Possibilities Within the Community of Inquiry Framework

Possibilités de conception pédagogique behavioriste-constructiviste dans le cadre de la communauté d'enquête

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Abstract

The discourse on blended learning must not take away focus on learning by concentrating explicitly on technologies. When learner-centred discussions are incorporated, these may be confined to constructivist pedagogies, as evident through the well-established community of inquiry (CoI) framework. While a few early advances argue for behaviourist pedagogies to underpin the CoI framework in particular, and a plethora of literature supports behaviourist-constructivist interplay for blended learning in general, this study pioneers the proposal of these interactions within the CoI framework for blended learning. It also challenges the prevailing stand-alone socio-constructivist pedagogical design of the CoI framework to deal with the complexities of higher education by adopting a decolonial positionality. In this light, we explain the impact of missing out on behaviourist designs on the CoI framework through the problem of epistemological untenability and that of assumed learning. Having provided the rationale for including behaviourist designs, we then emphasize the behaviourist-constructivist interactions within the framework. This discussion paper contributes to the ongoing dynamic scholarship of the CoI and encourages the research community to empirically explore the positioning of such a pedagogical design within this framework.

Keywords: behaviourism, blended learning, community of inquiry framework, constructivism, higher education, socio-constructivism

Résumé

Le discours sur l'apprentissage hybride ne doit pas détourner l'attention de l'apprentissage en se concentrant explicitement sur les technologies. Lorsque des discussions centrées sur la personne apprenante sont intégrées, elles peuvent se limiter à des pédagogies constructivistes, comme le montre le cadre bien établi de la communauté d'enquête (CE). Alors que quelques avancées précoces plaident en faveur des pédagogies behavioristes pour étayer le cadre de la CE en particulier, et qu'une pléthore de littérature soutient l'interaction behavioriste-constructiviste pour l'apprentissage hybride en général, cette étude est la première à proposer ces interactions dans le cadre de la CE pour l'apprentissage hybride. Elle remet également en question la conception pédagogique socioconstructiviste indépendante qui prévaut dans le cadre de la CE pour traiter les complexités de l'enseignement supérieur en adoptant une position décoloniale. Dans cette optique, nous expliquons l'impact de passer à côté des conceptions behavioristes dans le cadre de la CE à travers le problème de l'insoutenabilité épistémologique et celui de l'apprentissage présumé. Après avoir justifié l'inclusion des conceptions behavioristes, nous mettons l'accent sur les interactions behavioristes-constructivistes au sein du cadre. Cet essai contribue à la recherche dynamique en cours sur la CE et encourage la communauté de recherche à explorer empiriquement le positionnement d'une telle conception pédagogique dans ce cadre.

Mots clés : apprentissage hybride, béhaviorisme, communauté d'enquête, constructivisme, enseignement supérieur, socioconstructivisme

Introduction

The burgeoning importance assigned to technologies seems to have displaced the essence of learning from blended learning (BL), thereby seemingly reducing it to a buzzword (Cronje, 2020). This is because the recent discourse on BL seems to favour the for-profit edtech companies, leading to newer and deeper challenges at the intersection of e-privatization, learning, and equity (Kerssens & van Dijck, 2023). As a result, pedagogy is rarely the driving force behind discussions on BL (Littlejohn & Pegler, 2007). However, it is crucial to understand the state of BL through pedagogical assumptions (Vaughan et al., 2023) so that technologies are employed based on robust knowledge rather than on serendipity (Shield, 2000). Having said this, the conceptualisation of BL by the community of inquiry (CoI) framework (Garrison & Vaughan, 2008; Vaughan et al., 2013; Vaughan et al., 2023) is enriched, considering it to be a thoughtful integration of face-to-face learning with online learning in the socio-constructivist realm. While the CoI makes initial attempts to integrate the concept of learning in BL by embedding the conceptual framework in socio-constructivist pedagogies, this theoretical discussion raises the possibility of broadening the underpinning pedagogical design. The overarching question shaping this discussion is: Could the CoI framework be (re)thought beyond socio-constructivism based on the reinvigorated pedagogical assumptions of behaviourist-constructivist interactions?

This discussion paper acknowledges the early advances favouring the behaviourist stance in the CoI framework (Annand, 2019; Gregory, 1999), supported by the literature questioning the success of teaching-learning underpinned by constructivist designs only (Brandstedt, 2023), though not necessarily sourced from the CoI framework. Evidence regarding learning in resource-crunched context suggests behaviourist-constructivist pedagogies are more effective than the popular constructivist designs (Cronjé, 2000, 2006; Cronje, 2020). Building on the above-mentioned literature, this discussion paper aims to question the prospects of behaviourist-constructivist interactions for BL within the CoI and presents theoretical arguments asserting the possibilities of rethinking the framework.

Learning in practice is complex, especially in blended spaces, demanding pedagogical designs be responsive to the socio-cultural context requirements in which the learners are located. Therefore, this discussion paper raises the possibility of an *interactionist CoI (i-CoI)* framework rooted in behaviourist-constructivist interactions instead of in a socio-constructivist design. Though “behaviourist” is often used interchangeably with "instructivist," "objectivist," or “traditional approach,” for the sake of coherence, this discussion paper uses the term “behaviourist” to denote the perceived opposite of the constructivist approach. Likewise, the term “socio-constructivism” over “collaborative constructivism” is used to draw coherence with literature beyond the CoI framework (Kanuka & Anderson, 1999; Milad, 2019; UC Berkeley, 2021).

Five aspects of comparison between these two positions are noteworthy (Willis, 1995): 1) the learning process for behaviourists is linear and sequential, while the process for constructivists is recursive, non-linear, and chaotic; 2) behaviourists employ top-down planning, while constructivists believe in organic, collaborative, reflective, and developmental planning; 3) learning objectives for behaviourists are decided in advance and are employed to guide development, while those for constructivists are emergent and evolve during design and development; 4) learning for behaviourists entails preselected knowledge transmission, while constructivists emphasize knowledge construction within meaningful contexts; and 5) behaviourists give more weight to summative evaluation and objective data, while constructivists suggest formative evaluation and subjective data are crucial. Similarly, Tam (2000) summarises the different epistemological positions adopted by behaviourists and constructivists. Behaviourists believe that knowledge exists in the physical world, outside the mind of the individual, and is objective. Whereas constructivists believe that knowledge is personal and created by people rather than existing outside of the human mind.

Although we provide theoretical assertion for the i-CoI framework, its empirical verification or construction is beyond the scope of this discussion paper. However, discussion may further encourage researchers to empirically consider, if present, how the behaviourist-constructivist interactions could influence the CoI framework in practice, and possibly nudge them to think about developing the evidence-based i-CoI framework. Further, this discussion paper has potential implications for redesigning context-specific and theoretically informed BL courses for traditional and distance education practitioners and researchers with a mix of behaviourist and constructivist designs.

Context

Popular worldview on conducting technology-enabled learning research for development is informed by countries in the Global North. Although this research aims to enhance the quality of and access to higher education, the challenge begins when applying these theories or methodologies, unaltered, in the Global South, as the socio-cultural context is not the same (Brown et al., 2024). Researchers have called for the decolonization of such research (Brown et al., 2024; Masiero, 2022) by including Southern voices. This discussion paper attempts to propose possibilities to decolonize the well-known CoI framework, particularly for BL research. Two important questions are addressed: a) How can it be ascertained if the CoI framework does not encompass the Southern voices? and b) if so, what can be done to decolonize the CoI framework?

There is significant evidence that the CoI framework is reliable and internally valid (Garrison et al., 2006). Garrison et al. (2004) and Arbaugh (2007) used factor analysis to confirm the structure of the seminal CoI process model. Moreover, it has been found that the three CoI presences are positively related to learning outcomes, including actual and perceived learning, as well as learner satisfaction (Akyol & Garrison, 2008; Martin et al., 2022). However, Garrison et al. (2006) highlight concern regarding the framework's external validity. Guba (1981) explains that in both rationalist and naturalistic stances, the external validity could be assured through context-relevant findings. In other words, a lack of external validity in the CoI possibly points towards diminished context-specific variations. To further ascertain this, the following two supporting pieces of evidence are highlighted. First, the review by Castellanos-Reyes (2020) underscores that the majority of CoI applications are found in American and Canadian contexts. Second, a search on the Web of Science database[1] shows that 4 out of 10 studies related to the CoI framework emerge from the Global South, with only 1 out of 10 studies emerging from countries other than China. The analysis shows that the lack of external validity could be due to its limited application in the Global South, and therefore, we propose that the CoI encompass other voices.

Garrison eloquently remarks,

> I think one of the main problems with CoI research is the tendency to consider every online/ blended learning environment is a true community of inquiry design when, in fact, there is little teaching, cognitive, or social presence (students are reliant on independent activities and texts). (2012, p. 250)

Do these assumptions restrict applying the CoI framework in Global South? We argue that the enriched scholarship provided by the CoI framework could provide direction to enhance different presences, even if compromised in some contexts. However, for that, we need to deeply dissect how the CoI framework can be used more broadly in the Global South context.

For this, we move to the second question. This limitation of not sufficiently attributing southern voices could potentially be linked to the framework's underlying intellectual roots of socio-constructivism in the light of the behaviourist-constructivist divide. It is important to underline that this debate erupted in the Global North context, and in the discourse, the voices from other regions are relegated to the periphery (Cronje, 2006). In support of including the diverse contexts, Spector raises a pertinent question, "Where are the African, Asian, European, Pacific Islander, and South American voices in this dialogue?" (2004, p. 48). Spector expands on positioning the arguments to decolonize the CoI framework, specifically in BL contexts.

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[1] The search query comprised of the following keywords: TS=[("Community of inquiry") AND (framework OR model OR survey OR Scale)]. A total of 450 studies between 2004-2024 were analysed by classifying countries as Global North or South following the criteria set by the United Nations (2022), as used in earlier studies (Sareen & Mandal, 2024).

The Community of Inquiry Framework: Paradigmatic Assumptions

The CoI framework, which is widely researched and implemented (Yu & Li, 2022) helps understand the shaping of higher-order learning within different forms of education, including blended higher education (Garrison & Vaughan, 2008; Vaughan et al., 2013; Vaughan et al., 2023). In the CoI, BL is defined as "the organic integration of thoughtfully selected and complementary face-to-face and online approaches and technologies" (Garrison & Vaughan, 2008, p. 148). The CoI is derived from Garrison et al. (2000) seminal work for understanding the educational experience in online spaces and is shaped by the concurrence of three presences: cognitive, social, and teaching. Cognitive presence, an established and undisputed element, is "the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse in a critical community of inquiry" (Garrison et al., 2001, p. 11). It is a four-phased process comprising triggering events, exploration, integration, and resolution (Garrison et al., 2001). Beyond the cognitive presence, social presence (Lipman, 1991; Garrison, 2015) creates a constructive environment for expression of emotion, open communication, and group cohesion. Teaching presence is the cohesive element that ushers in the advancement of a managerial role through its three categories, namely, designing, facilitating discourse, and direct instruction.

The CoI is grounded in the socio-constructivist stance of John Dewey where education is viewed as having dual sides, that is, psychological and sociological, wherein neither could be neglected or treated as subordinate to the other (Swan et al., 2009). Anderson (2017) explains that the motivation for developing the seminal CoI model rooted in socio-constructivist design was to include cooperative and collaborative learning, which did not gain much prominence in the earlier behaviourist designs. This growing focus towards the collaborative dimensions of learning was because the potential of social learning activities like peer-to-peer interaction and study groups had been validated by that time through extensive research in classroom-based learning. With more research, the CoI expanded from online (Garrison et al., 2000) to blended learning (Garrison & Vaughan, 2008; Vaughan et al., 2013; Vaughan et al., 2023), although with unchanged underpinning assumptions of socio-constructivist designs which remain largely uncontested (Annand, 2019).

Changing Pedagogical Trends in Blended Learning Discourse

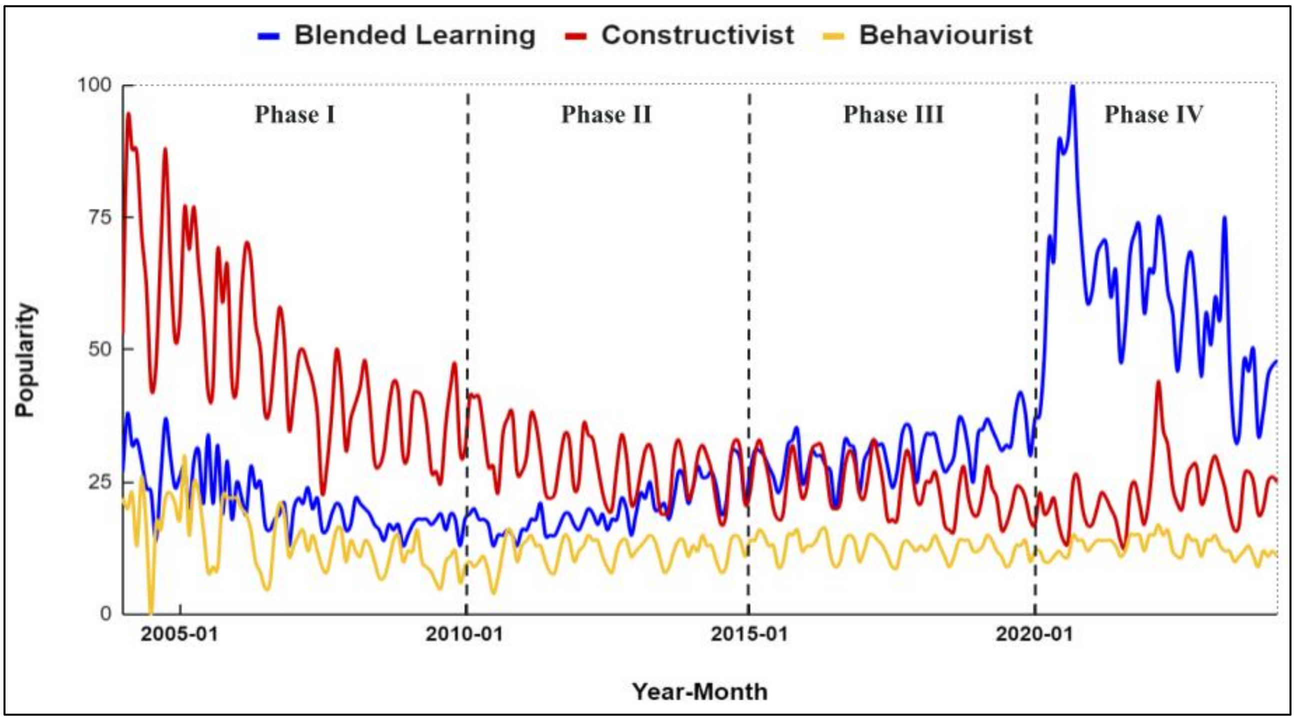
Locating BL discourse within socio-constructivist pedagogy is not unique to the CoI framework. Through trend analysis from 2004–2024, constructivist designs show gained prominence in the BL discussions over behaviourist designs. The unfolding of BL literature regarding pedagogies is outlined in Figure 1, elaborated below through the four evolutionary phases. The classification into behaviourist, constructivist, and BL emerged from the search interest through the data obtained via Google Trends.

In the first phase, prior to 2010, behaviourist designs dominated BL discourse, as shown by the overlapping of their lines in Figure 1. The constructivist designs which had become popular were still being researched (Adams, 2006; Terhart, 2003), without much intersection with BL discourse. During this time, there was noticeable ambiguity in understanding BL, including a lack of agreement on its key terms (Driscoll, 2002; Graham, 2006; Sharpe et al., 2006; Valiathan, 2002; Whitelock & Jelfs, 2003).

Nevertheless, what remained unchallenged was the genesis of educational technology, a crucial part of BL, which was rooted in behaviourist pedagogies. The behaviourist tendencies in educational technology can be exemplified through the design of modern-day online education software programs resembling Skinner's teaching machine of 1958, shaped by programmed learning and meant to reinforce students' behaviours (Shield, 2000).

Figure 1

Relative Popularity Trends of Blended Learning, Constructivist, and Behaviourist Designs



Note. The graph is plotted based on search interest through the 2004-2024 data obtained via Google Trends. This graph is the authors' own image.

The second phase (2010-2015) saw a gradual increase in the interest in BL. This was a transitory phase when the discussion regarding the behaviourist roots in BL discourse was declining, replaced by discussions regarding constructivist designs (Weegar & Pacis, 2012). This shift is evidenced by the increasing gap between the BL and behaviourist design popularity followed by BL approaching and overlapping with that of constructivist designs (Figure 1). After this phase, the behaviourist designs lost popularity in BL discourse (Ojeaga & Agbi, 2015).

The third phase (2015-2020) showed a predominance of constructivism in BL discourse, observed through overlapping between the lines representing BL and constructivist designs (Figure 1). This is also the time when the first volume concerning CoI and BL, titled *Blended learning in higher education: Framework, principles, and guidelines* (Garrison & Vaughan, 2008), was gaining popularity, and the second volume in the series, titled *Teaching in blended learning environments: Creating and sustaining communities of inquiry* (Vaughan et al., 2013), was released. Both volumes locate BL in socio-constructivist designs, thus reiterating the increased popularity of constructivist designs in BL discussions.

The fourth phase, after 2020, in which the popularity of BL increased substantially, saw two major trends in pedagogies, that is, a) receding discussions at the intersection of pedagogies and BL, followed by b) constructivist designs finding their way back. This may be because the global pandemic was accompanied by an increased focus on technologies that relegated learning to the periphery, inviting renewed interest from ed-tech corporations (Brown, 2021). This meant that neither behaviourist nor constructivist designs formed a major part of BL scholarship during the initial part of this phase, as it was dominated by political and economic agendas of the platforms (Artopoulos, 2023). In other words, the personal interests of the for-profit ed-tech corporations overshadowed the learning process. This could be observed through a significant increase in the search interest regarding BL, leaving behind the interest in the constructivist and behaviourist designs, as seen in Figure 1. Critical scholarship followed, wherein researchers and educators argued for bringing learning back into BL, as witnessed from the interest in BL approaching that of constructivist designs. In this regard, Cronje (2020) writes

> it seems that few authors notice the irony that the definition of blended learning does not include the concept of learning at all. The problem with these definitions is that they are devoid of theory and thus lead to trial-and-error research. (p. 114)

Having said this, only the constructivist designs, to some extent, could find their place back in the recent BL discourse. This trend is supported by the release of the third volume on CoI and BL advocating for constructivist designs, titled *Principles of blended learning: Shared metacognition and communities of inquiry* (Vaughan et al., 2023).

Therefore, this section poses the central problem of behaviourist designs losing popularity in BL discussions due to the over-emphasis of technologies over pedagogies in general and among the pedagogical designs, the popularity of constructivist design pushing back behaviourist designs.

Why is Missing Out on Behaviourist Design a Problem?

This section highlights two problems that may arise because of the deficit of behaviourist designs underpinning the CoI framework for BL. The first issue focuses on philosophical concerns and the second on practice-related challenges.

Challenge of Epistemological Untenability

The seminal CoI framework (Garrison et al., 2000) was originally developed for online spaces, informed by socio-constructivist pedagogy. It was eventually extended to blended spaces; however, the underlying assumptions of socio-constructivist designs were not altered. In this paper, we call this the problem of epistemological untenability in the CoI framework for BL, as the pedagogical design shaped by one of the contributing epistemological assumptions in BL (i.e., classroom learning) is not accounted for in the CoI. Blended learning can be understood to be a homogenous mixture. For BL, the online and in-person segments are mixed thoughtfully, and while these segments retain their individualism, they also contribute to comprehensive knowledge generation in a complex space. Unlike a compound with a fixed composition of its constituent elements, BL could be tailored and customized to learner needs and the socio-cultural context. In the same manner, particularly in the context of Global South, how feasible would it be to assert that the CoI is only underpinned by socio-constructivism? It may be worth considering the other theories that contribute to the complex whole that forms learning. It is crucial to question the tenability of leaving behaviourist designs which shape both classroom and online pedagogies in this narrative.

Understanding BL as a thoughtful mixture over a compound is not linear. Two contrasting spaces are integrated (Adams, 2006; Kanuka & Anderson, 1999), each packed with different epistemological assumptions (Ahmad et al., 2020; Bednar et al., 2013). This combination of placing behaviourist and constructivist pedagogies together has been ruled out in the past (Jonassen, 1991; Khan & Nawaz, 2010). In Jonassen's (1991) linear approach, also called the mid-point approach, the two paradigms are at the two ends of a continuum (Vrasidas, 2000). If this continuum model is adopted, the co-existence of these paradigms would not be possible because, at any point in the continuum, if one component increases, the other is bound to decrease. This would imply that the instructor could either follow a behaviourist or a constructivist approach. However, this approach would not be inclusive as some learning activities may simultaneously have low or high behaviourist and constructivist characteristics (Cronjé, 2006). Consider the case of learning abstract mathematics. Lectures and drills and practice at the individual level usually proceed before group discussions to make sense of the critical discourse, with constant swaps between these positions. In such a case, this mid-point approach fails to cater to the complexities of BL. Given such possibilities, we propose placing behaviourist and constructivist designs together.

For this, we investigate more cases where traditionally refuted concepts are integrated together and take refuge in a similar case of mixed methods research. Herein, the contributing elements–quantitative and qualitative–have different worldviews. While the quantitative domain falls within positivism or post-positivism, asserting objective reality, the qualitative domain embraces a naturalistic stance, endorsing subjective reality. It was only after several decades of debate that researchers showed consensus on retaining both worldviews in mixed methods research, contingent on the study design. Today, mixed methods research is known for high credibility and robust analyses (Creswell & Clark, 2018).

Drawing from this example, it may be appropriate to posit that BL could be a thoughtful experience by retaining the epistemological assumptions of both contributing segments. By using the term “thoughtful” in the BL definition (Garrison & Vaughan, 2008, p. 148), it is implied how the learning experience is approached (Vaughan et al., 2023). In other words, the epistemology of face-to-face and online segments is underscored. The epistemology means “how to perform or “do” in a domain” (Kirschner, 2009, p. 151). These epistemological beliefs of a domain may shape the pedagogies for teaching (Lammassaari et al., 2021; Stoddard, 2010), i.e., “how to learn or be taught in a domain” (Kirschner, 2009, p. 151). This implies that the epistemological assumptions of face-to-face and online learning for BL may shape the pedagogical designs chosen in practice. Next, we explain that the epistemological beliefs about face-to-face learning shapes behaviourist pedagogies, while online learning shapes constructivist and behaviourist pedagogies. For BL, if both the epistemological beliefs underpinning face-to-face and online learning are to be retained (like in the case of mixed methods research), then both behaviourist and constructivist pedagogies may need to be included.

However, looking closely into the CoI framework for BL, we see a "problem of missing out" on behaviourist pedagogies. As a solution to this philosophical issue, we propose including behaviourist designs in the CoI framework for BL.

Epistemological Assumptions Shaping Pedagogies

Before the second point further explains the practice-related challenge of assumed organic learning, we explain how the epistemological beliefs about the two segments of BL shape pedagogies. Through a chronological analysis, we find that the epistemologies underpinning face-to-face learning majorly shape the behaviourist pedagogies, while those nurturing online learning shape both the constructivist and behaviourist pedagogies.

In earlier days, learning was seen as knowledge transmission, encompassed by the behaviourist paradigm. However, the advent of interactive technologies, including online learning, shifted the focus to knowledge building, as entailed by the constructivist paradigm. Cullen et al. (2002) explains that in the twenty-first century, educational research is experiencing a paradigm shift from traditional didactic approaches to constructivist pedagogy, grounded in four pedagogic methodologies: expository, interactive, conversational, and experiential methods. This shift could be illustrated through the techno-pedagogical matrix developed by Anderson and Dron (2011), which maps traditional technologies like mass media, print, or radio with behaviourist designs and advanced technologies like web conferencing with constructivist designs. Given that most innovative methods embrace technology (White-Clark et al., 2008), the shift from behaviourist to constructivist designs aligns broadly with the shift from traditional face-to-face teaching to technology-enabled learning by virtue of genesis.

This paradigmatic shift is grounded in epistemological differences. Behaviourists recognize how external environments can alter behaviour and lead to learning, thus associating the epistemology of physical space with behaviourist designs. However, in the case of online learning, external space is not a tangible space like brick-and-mortar. Therefore, this innovative space seems to have more affinity to constructivist designs (Blanchette & Kanuka, 1999).

The epistemological assumptions of online learning with constructivist pedagogies are not that discrete, however, as we also see possibilities from the literature on associating behaviourist pedagogies with online learning. This could be explained through the example of Skinner's teaching machine (Shield, 2000) which allows for reinforcement in online learning. This becomes more pronounced with virtual space providing scope for synchronous online communication. It also allows for the integration of rewards and punishment systems in real-time (Weegar & Pacis, 2012), thus leading to the possibility of relating the epistemology of online spaces to behaviourist pedagogies.

Challenge of Assumed Organic Learning

Grounding in practice (Vaughan et al., 2023), conveyed by the term "organic" in the BL definition (Garrison & Vaughan, 2008, p. 148), could be an assumed idea in the absence of behaviourist pedagogies. Vaughan et al. (2023) espouses that "if we are to deal with the theoretical and practical complexities of rethinking the educational experience from a blended learning perspective, then the first challenge is to provide conceptual order that goes beyond rigid, non-reflective recipes" (p. 11). We may surmise the mention of *rigid, non-reflective recipes* to behaviourist designs and underscore their narrow understanding. These are not necessarily

> static and unchanging, nor does it imply that the mental representations of it in individual minds will be identical copies. Depending on personal perception, there will be variation in dimensions such as quality and depth of understanding, emotional presence and personal opinion, but they have to share the essential features if they are to be called knowledge of the same thing. (Brandstedt, 2023, p. 1571)

Thus, behaviourist pedagogies may not be as ominous (Gregory, 1999) as portrayed in constructivist literature.

It is unsurprising that constructivist designs remain largely unchallenged in literature. For example, Brandstedt (2023) discussed how astronomy could be taught by reading a book, which would align more with behaviourist stance, or by observing the movement of the sun and shadows, representing the constructivist stance. While adopting the second stance may be appealing, doing it in the absence of the first stance may paint an impractical and "romanticised and unrealistic picture" (p. 1572). It may be equivalent to disregarding the years of systematic observations and analyses to produce the astronomic theories.

Brandstedt (2023) notes, "But even though teachers cannot build their students' knowledge for them, they can provide them with more than just scaffolding; they can provide building materials and blueprint too" (p. 1573). The scholar critiques the idea of simply handing materials to the students in either modality, and leaving them to their own devices with the mirage of learning. Thus, in practice, leaving behaviourist designs under the assumption of stand-alone constructivist designs being sustainable enough may not lead to holistic and effective teaching-learning.

COI Framework and Behaviourist Pedagogies: Three Green Flags

Having explained the reasons for missing out on behaviourist designs in the CoI framework and its impact, three early pieces of evidence from the literature embracing the possibilities of behaviourist pedagogies in the CoI framework for BL are provided. While not exhaustive, this list is sufficient to (re)consider the CoI framework's fundamental assumptions. First, Gregory (1999) hinted towards a behavioural pedagogy for the CoI framework by remarking "we save the community of inquiry for the last, and do a detailed behavioural analysis of its virtues" (p. 35). The central virtues considered are cognitive, affective, democratic, and semantic. Annand (2019) adopted a slightly different approach, not reaching a very different conclusion about the CoI framework emerging from an objectivist paradigm, in which behaviourist theories could arise. Annand's primary argument goes back to the development of the seminal CoI framework drawn from asynchronous text-based computer-conferencing transcript analysis, reasoning that transcript analysis is a common means adopted in the behaviourist paradigms. Further, Anderson (2017) expresses surprise at the applicability of the CoI framework in behaviourist settings (e.g., in the case of xMOOCs).

Behaviourist-Constructivist Interactions in the CoI Framework

This discussion paper proposes that behaviourist-constructivist interactions underpin the CoI framework for BL. In this section, we move forward to suggest how these two pedagogies could be placed together within the CoI framework and offer broader constructivist designs as an alternative to the socio-constructivist designs advocated in the CoI.

Constructivist Designs Versus Socio-Constructivist Designs

Constructivism describes a coherent set of theories connected by active learning (Adams, 2006) and entails different positions with socio-constructivist designs being one (Kanuka & Anderson, 1999). Two typologies of constructivism–cognitive and social–have gained immense popularity. This can be attributed to the substantial change occurring in the foundational understanding of learning from converging on external behaviour (behaviourist) to focusing on mental processes (cognitive constructivism) and, subsequently, an impetus to focus on shared construction of knowledge (socio-constructivism) (Milad, 2019; UC Berkeley, 2021). Socio-constructivism locates an individual within a socio-cultural context and concentrates on shared knowledge by means of conversational language and social negotiation, acknowledging multiple realities through shared meaning (The Cognition and Technology Group at Vanderbilt, 1991).

Vygotsky is critical of disregarding the cognitive role while considering the socio-cultural learning contexts (Fosnot & Perry, 1996; Wolsey & Fisher, 2009). Similarly, Cobb's (1994) theoretical ideas indicate coherence between cognitive and social constructivism, espousing that knowledge construction through social interaction takes place in the learner's mind (cognition). Therefore, defining constructivism has been difficult (Weegar & Pacis, 2012), but there is some agreement, if not complete, between its different branches. These various constructivist positions are upheld by the idea of "construction" (Terhart, 2003, p. 29). Two core presumptions that unite these distinct positions are creating knowledge from prior experiences and active learning (Kanuka & Anderson, 1999). Thus, (re)emphasizing the commonalities between these strands, we proceed with the core understanding of constructivism.

Behaviourist-constructivist interactions embrace both pedagogical designs to have strong implications for shaping context-based teaching and learning practices. These interactions come with the fundamental assumption that neither thought is flawed, as the behaviourist-constructivist divide is a problem of a false dichotomy. This paper is guided by Cronjé's (2000, 2006, 2022) and Cronje's (2020) perspective that these two approaches are complementary rather than opposite. Cronjé (2006) points out that the emotionalization of the behaviourist-constructivist divide is caused by the exaggeration of new ideas by distorting and denigrating traditional paradigms. Therefore, we must not only de-emotionalize the behaviourist-constructivist divide but also understand the interactions more deeply and situate them in specific socio-cultural contexts.

Van Merriënboer and Kester, as cited by Elander and Cronje (2016), note that "researchers should always have an open mind for research based on competing theories and paradigms because radically new ideas and perspectives will most likely develop at the interface between paradigms"

(p. 390). This paves the way towards cherishing the behaviourist-constructivist interactions as an alternative to stand-alone constructivist designs (Campbell et al., 2020; Chou, 2020; Cook, 1993; Elen, 2017; Philips, 1995). Similarly, numerous researchers have attempted to explain the bridge between the two paradigms, thereby supporting the idea that learning employs the usage of elements from both sides (Smith & Ragan, 1999). For instance, Rieber suggests “microworlds” (1992, p. 93) to connect the two positions, while Alessi and Trollip (2001) propose a triangle joining behaviourism, cognitivism, and constructivism. Vrasidas (2000) offers a pragmatic view by remarking that, in practice, these paradigms co-exist and are employed depending on the need to change to be more linear or holistic.

Drawing upon Vrasidas’s ideas, Cronjé (2000, 2006) proposed the matrix model for integrating behaviourist and constructivist pedagogies in a complementary and harmonious manner by placing them orthogonally to each other. Cronjé’s (2000, 2006) quadrant model places the two paradigms at right angles, i.e., behaviourism at the x-axis and constructivism at the y-axis, resulting in four quadrants. Moving anti-clockwise, the first quadrant is high in both paradigms by design and is referred to as the “integration” quadrant; the second quadrant is high in constructivism and is called as “construction” quadrant; the third quadrant is low in both paradigms and is referred to as the “immersion” quadrant; and finally, the fourth quadrant is high in behaviourism and is called the “injection” matrix. Elander and Cronje (2016) note the resonance of this four-quadrant model (Cronjé’s, 2000, 2006) with the conceptual framework developed to aid decision-making, called the Cynefin framework (Kurtz & Snowden, 2003).

Cronjé (2000, 2006, 2022) and Cronje’s (2020) work aids in explaining the nuanced behaviourist-constructivist interactions. This modified CoI framework rooted in these interactions instead of socio-constructivist designs is called the interactionist-community of inquiry (i-CoI) framework. Thus, the idea of the i-CoI framework could aid in optimizing learning in a given socio-cultural context (Cronje, 2020), possibly making this framework more “thoughtful” and “organic” in the context of BL.

Conclusion

This discussion paper highlights the central challenge of behaviourist designs taking a backseat in BL discourse because these are outweighed by the popular constructivist designs and further impacted by the importance afforded to technologies over learning. However, we argue for the importance of behaviourist designs in BL because of the complex nature of learning. This discussion is systematically developed by taking a decolonial positionality, particularly in the context of the CoI framework for BL and rooted in two theoretical arguments. The first argument underscores the problem of epistemological untenability by leaving behaviourist designs, thus proposing its placement with constructivist designs.

The second argument highlights the problem of assumed learning in the absence of behaviourist pedagogies. It is proposed that behaviourist designs, through behaviourist-constructivist interactions, are included in the i-CoI framework. It is assumed that the i-CoI framework may more comprehensively cater to student learning needs from diverse backgrounds and could possibly be adapted for various contexts.

Notably, limitations of this study exist. First, despite the wider applicability of the CoI framework, this discussion paper is restricted to BL contexts. Second, this study raises questions but does not advance in further analysis. Researchers are urged to continue to study behaviourist-constructivist interaction possibilities in the CoI framework and to understand the role of emerging theories like connectivism, paving the way for the CoI to become a learning theory for BL.

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Formation initiale des enseignants : explorer le potentiel d'un robot de téléprésence

Preservice Teacher Training: Exploring the Potential of a Telepresence Robot

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Résumé

Lors de la formation initiale en enseignement, il arrive fréquemment que des classes universitaires se déplacent en milieu scolaire afin de créer des liens entre les apprentissages théoriques (effectués dans le cadre des cours universitaires) et la pratique. Cependant, dans le contexte de la pandémie de COVID-19 et des diverses mesures sanitaires de la santé publique, la formation pratique des étudiantes et des étudiants en éducation dans les établissements scolaires n'a pu avoir lieu. C'est dans cette perspective qu'un projet de recherche a été réalisé pour étudier l'enseignement à distance par le biais d'un robot de téléprésence. À partir de leur campus respectif, 17 étudiantes et étudiants ont enseigné des concepts à des élèves des écoles environnantes, et ce, en contrôlant un robot. Les résultats de l'analyse thématique montrent qu'il a été possible d'interagir avec les élèves lors de l'enseignement et que les étudiantes et les étudiants en formation ont acquis des connaissances pédagogiques liées à l'enseignement au cours de cette expérience pratique. Cette étude démontre que cette expérience novatrice a permis de parachever les apprentissages théoriques du cours universitaire.

Mots-clés : enseignement à distance, expériences pratiques en milieu universitaire, formation initiale en enseignement, robot de téléprésence

Abstract

In preservice teacher education, university courses often venture into the classroom to connect theory with practice. However, during the COVID-19 pandemic and the related public health measures, teacher training experiences in the field were discontinued. This research project was conducted to study distance teaching with the help of a telepresence robot. From their respective campuses, 17 preservice teachers were able to practice teaching in local schools using this mobile tool. Results of a thematic analysis reveal that it was possible for the preservice teachers to interact with the students during their teaching and that the preservice teachers acquired pedagogical knowledge related to teaching during this practical experience. The study also shows that this innovative practice complemented the theoretical learning activities of the preservice course.

Keywords: distance teaching, preservice teacher training, practical experiences in a university environment, telepresence robot

Introduction

En formation initiale en enseignement, dans les diverses universités au Canada, les étudiantes et les étudiants suivent des cours théoriques portant sur des domaines de formation générale et d'autres reliés spécifiquement à la profession enseignante (Lepage et al., 2015). De plus, divers stages pratiques en milieu scolaire (stage professionnel) ont lieu en cours de formation (Pelletier, 2020). Les stages en enseignement ont pour but de mettre en pratique les acquis théoriques universitaires (Desbiens et al., 2019; Patroucheva, 2014). Plusieurs recherches (Desbiens et al., 2009; Gervais & Desrosiers, 2005; Malo, 2011; Tardif et al., 2021) soulignent que ces stages sont considérés comme l'expérience la plus pertinente du programme de formation.

Malgré ces stages de formation, les étudiantes et les étudiants font souvent état du manque de liens entre les apprentissages théoriques en cours et les apprentissages pratiques qui ont lieu dans le milieu scolaire (Desbiens et al., 2019; Freiman et al., 2023; Horn & Campbell, 2015; Lepage et al., 2015). Il semble exister un décalage entre le contenu de la formation universitaire et la réalité dans les écoles (Gravett & Ramsaroop, 2017). Les étudiantes et les étudiants soulignent qu'ils ne sont pas bien préparés pour gérer la complexité du travail qu'ils ont à réaliser au quotidien dans leur classe et dans leur école (Gravett & Ramsaroop, 2017; Tardif et al., 2021).

Ce manque de liens entre la théorie et la pratique (Hobson, 2003) peut engendrer des problèmes sur le plan de l'insertion professionnelle où l'on remarque un « taux d'abandon de la profession enseignante particulièrement élevé dans les cinq premières années d'exercice » (Pelletier, 2020, p. 397). Ceci pourrait être expliqué en partie par le fait qu'il n'y a pas suffisamment de liens entre les travaux demandés dans les cours universitaires et ceux exigés dans les écoles (Gravett & Ramsaroop, 2017).

C'est dans cette perspective que de plus en plus d'expériences pratiques ont lieu dans le milieu scolaire. Cette formation en milieu de pratique s'ajoute aux divers stages effectués en cours de formation, et ce, dans le but d'offrir le plus de temps possible en salle de classe pour avoir la chance d'observer, expérimenter et ainsi bonifier les connaissances, les compétences et les attitudes envers la profession (McLoughlin & Maslak, 2003; Selen Kula & Demirci Güler, 2021). Plusieurs recherches (Cirillo et al., 2020; Cooper & Nesmith, 2013; Selen Kula & Demirci Güler, 2021) ont d'ailleurs montré que les expériences pratiques représentent des occasions importantes concernant le développement et l'apprentissage des futures enseignantes et des futurs enseignants.

Problématique

Les expériences pratiques sur le terrain dans le cadre d'un cours de formation initiale en enseignement ne sont toutefois pas toujours possibles. Dans notre cas, le contexte de la pandémie de COVID-19 de 2020-2022 nous a obligés d'annuler les expériences pratiques faisant partie des cours universitaires en raison des mesures sanitaires mises en place dans le système scolaire. Il ne fut donc pas possible pour les étudiantes et les étudiants de se présenter dans les écoles pour expérimenter des scénarios pédagogiques auprès des élèves du système scolaire.

Ce problème nous amena à réfléchir sur la possibilité d'utiliser des technologies numériques pour offrir des expériences authentiques avec des élèves tout en étant à distance. C'est dans cette perspective que cette recherche fût menée afin d'étudier l'enseignement à distance par un robot de téléprésence mobile. Il s'agissait d'analyser la perception que les étudiantes et étudiants avaient de leur expérience d'enseignement avec un robot, de vérifier s'il serait possible d'interagir avec les élèves lors de celle-ci et de déterminer les avantages et les défis de cette méthode d'enseignement. Sur le plan pratique, cette expérimentation avait pour but de permettre aux étudiantes et aux étudiants de mettre en pratique les apprentissages effectués dans leurs cours théoriques, malgré les restrictions sanitaires qui interdisaient leur présence dans les écoles.

Cadre conceptuel

Expériences pratiques dans le milieu scolaire

Les expériences pratiques représentent des situations pour lesquelles les étudiantes et les étudiants en éducation vont dans les écoles et mettent en pratique les théories et les notions apprises dans leurs cours universitaires (Cooper & Nesmith, 2013). Selon ces auteurs, les expériences pratiques, lorsqu'elles sont effectuées tôt dans le programme de formation, amènent de nombreux bénéfices, tels que « mettre en pratique les connaissances apprises dans les cours universitaires, d'en apprendre davantage sur le fonctionnement de la salle de classe et sur les différences des élèves et de collaborer et d'apprendre d'enseignantes ou d'enseignants expérimentés » (p. 167, traduction libre).

Les robots de téléprésence mobiles

Qu'est-ce qu'un robot de téléprésence?

Les robots de téléprésence sont constitués d'un écran (tablette informatique) et de caméras positionnées sur un socle motorisé ayant des roues sous la partie inférieure qui lui permettent de se déplacer, et il est possible de les commander à distance à partir d'un ordinateur, d'une tablette personnelle ou d'un téléphone portable (Batmaz et al., 2020; Dussarps et al., 2020; Lehmans et al., 2020). Plus précisément, le robot de téléprésence « dispose de deux caméras, une en hauteur permettant de voir ce qui se trouve devant lui "à hauteur d'homme", et une caméra au niveau du sol pour faciliter les déplacements et éviter les obstacles » (Dussarps et al., 2020, p. 124). La différence majeure entre les robots de téléprésence et les écrans conventionnels réside dans le fait qu'ils peuvent tourner à 360 degrés ainsi que se déplacer dans l'environnement ce qui permet plus d'interactions (Jakonen & Jauni, 2021; Khadri, 2021; Lei, 2021).

Les avantages de se sentir présent à distance

Le terme « téléprésence » est utilisé pour décrire les technologies qui permettent de se sentir socialement présent lorsque des utilisateurs communiquent ou interagissent avec des personnes à distance (Batmaz et al., 2020; Khadri, 2021; Liao et al., 2022; Petit et al., 2020). On décrit même ce phénomène comme une immersion dans laquelle l'utilisateur a la sensation d'être plongé dans le milieu, donc de se sentir présent (Dussarps et al., 2020).

Les robots de téléprésence sont souvent utilisés dans le milieu de l'éducation pour permettre à des élèves (malades, handicapés, accidentés) d'assister aux enseignements (Carmichael, 2023; Dussarps et al., 2020; Gallon & Abenia, 2018; Rinaudo, 2018). À cet effet, Dussarps et ses collaborateurs (2020) soulignent que beaucoup d'élèves n'auraient probablement pas persévéré à court terme dans leur scolarité, et ceci pourrait s'expliquer par le fait que les élèves gardent ainsi leur statut de pair dans la classe, malgré leur isolement.

Les robots de téléprésence comme outils de formation pour les étudiantes et les étudiants en éducation

L'utilisation des technologies et plus particulièrement des applications de vidéoconférence est de plus en plus populaire dans les milieux de l'éducation, et ce, même dans les établissements d'enseignement supérieur (Jakonen & Jauni, 2021). Il en est de même pour l'utilisation des robots de téléprésence « à cause du grand potentiel pour améliorer les expériences éducatives des utilisateurs à distance » (Khadri, 2021, p. 1, traduction libre).

Malgré cet engouement, les recherches sont rares concernant les effets de l'usage de robots de téléprésence et leur acceptation dans les milieux de l'éducation (Lehmans et al., 2020; Lei et al., 2021). Au niveau universitaire, quelques recherches ont été déployées. À partir d'expériences réelles d'usage des robots en contexte universitaire, Lehmans et ses collaborateurs (2020) ont proposé des pistes afin de sensibiliser et former les enseignantes et les enseignants aux différentes façons d'intégrer les robots de téléprésence, ce qui permet de s'assurer une meilleure inclusion des apprenantes et des apprenants. Les analyses de la recherche de Rinaudo (2018) ont montré que l'utilisation des robots de téléprésence amène un apport sur le plan pédagogique tout en étant vécue comme un processus de subjectivation. Dans leur étude, Jakonen et Jauni (2021) ont étudié comment les robots de téléprésence peuvent être utilisés afin de faciliter la participation des apprenantes et des apprenants dans l'enseignement des langues étrangères au niveau universitaire. Dans un contexte similaire, Liao et al. (2022) ont montré que les apprenantes et les apprenants ont vécu des expériences d'apprentissage positives même si les enseignantes et les enseignants étaient situés dans un autre pays. Quant à Lei et al. (2021), ils ont étudié la perception des universitaires envers l'utilité des robots de téléprésence, leur facilité d'utilisation ainsi que la norme subjective et les risques reliés à ceux-ci. Dans une autre étude, Khadri (2021) a montré le grand potentiel des robots de téléprésence et que ceux-ci ont un effet positif sur les activités éducatives, mais que de nombreux obstacles peuvent être rencontrés. Comme l'indique ce chercheur, d'autres recherches sont nécessaires en ce qui concerne « l'examen des perceptions des étudiantes et des étudiants concernant les apprentissages qui peuvent être réalisés via les robots de téléprésence afin de mieux comprendre le potentiel et les limites pédagogiques de ceux-ci » (p. 15, traduction libre).

Méthodologie

Cette recherche de type exploratoire est de nature qualitative.

Échantillon

L'échantillon pour cette recherche fut composé de 17 étudiantes et étudiants en deuxième année du baccalauréat en éducation. Ils étaient inscrits au cours *Apprentissage et enseignement* et provenaient de deux campus de l'Université de Moncton (campus d'Edmundston et campus de Shippagan) situés au Nouveau-Brunswick (Canada).

Déroulement de l'expérience

Au départ, les étudiantes et les étudiants furent initiés au projet de recherche par leurs professeurs. Par la suite, ils ont effectué la planification de leur enseignement. Finalement, le jour de l'expérimentation, au lieu de se déplacer physiquement dans l'établissement scolaire, les étudiantes et les étudiants ont effectué de l'enseignement à distance avec le robot de téléprésence qui fut apporté préalablement dans les écoles.

Outil de collecte de données

Après la réalisation de cette expérimentation auprès des élèves du système scolaire, les étudiantes et les étudiants ont répondu à un questionnaire (que nous avons construit) portant sur différentes thématiques (leur appréciation de l'expérience, les apprentissages effectués, etc.).

Méthode d'analyse des données

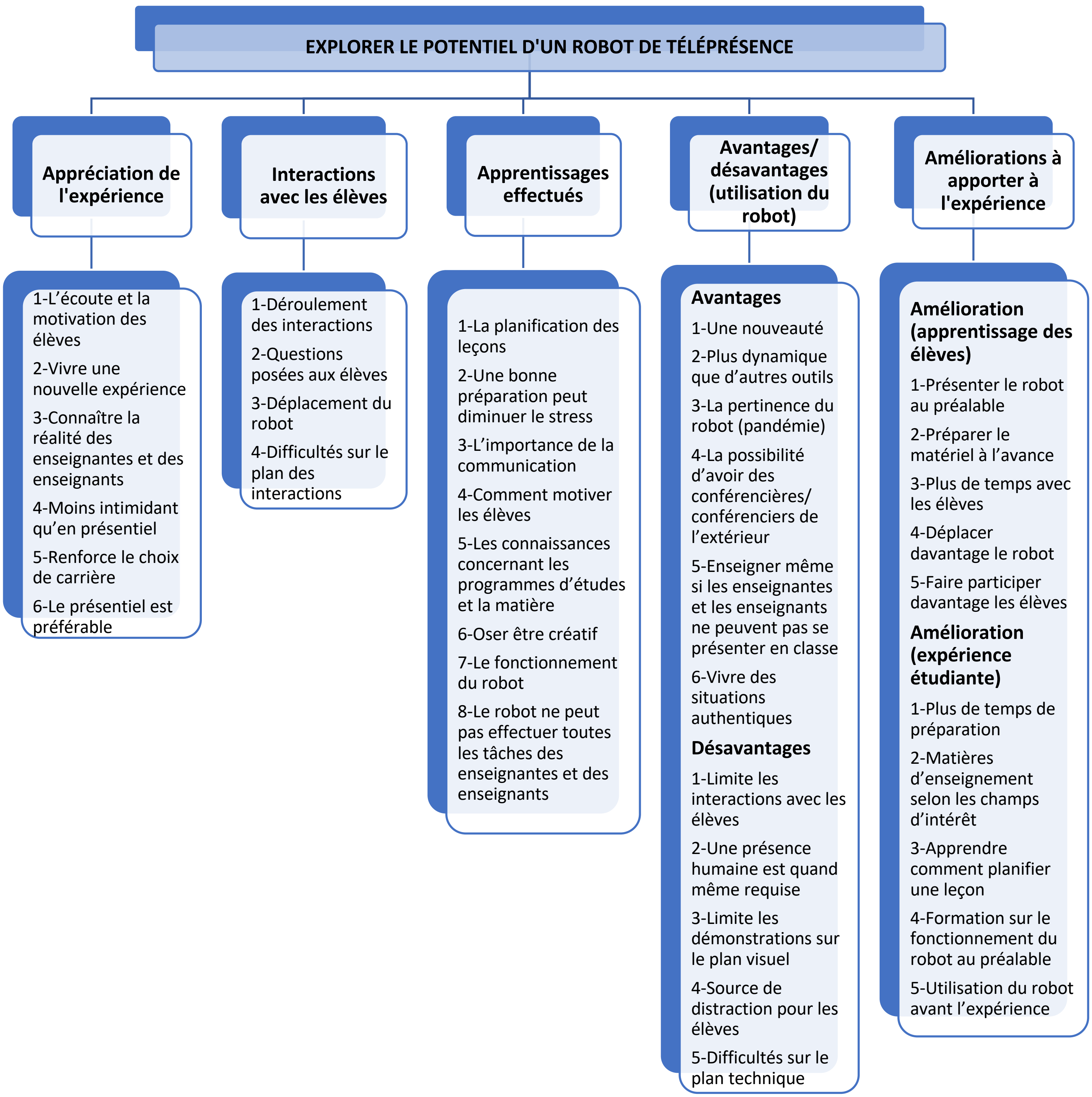
Nous avons effectué une analyse thématique dans laquelle des thèmes ont été attribués en lien avec les réponses obtenues au questionnaire (Paillé & Mucchielli, 2021). L'objectif principal de l'analyse thématique fut « la transposition d'un corpus donné en un certain nombre de thèmes représentatifs du contenu analysé, et ce, en rapport avec l'orientation de recherche » (Paillé & Mucchielli, 2021, p. 270). Cette transposition permet « de repérer, de classer, d'ordonner l'information » (Van der Maren, 2014, p. 205).

À la suite de l'analyse thématique, les résultats des analyses furent premièrement examinés pour une validation dans le temps (fiabilité intra-codeur). À l'étape suivante, les résultats furent traités par un examinateur externe (fiabilité inter-codeur). La fiabilité inter-codeur fut de 93,6 %, tandis que la fiabilité intra-codeur fut de 100 %. Ces résultats correspondent aux exigences de la fiabilité établies par Miles et Huberman (2003, 2014).

Résultats

Figure 1

Perception des étudiantes et des étudiants



Appréciation de l'expérience

Les étudiantes et les étudiants ont perçu positivement l'expérimentation auprès des élèves par l'entremise du robot de téléprésence mobile.

> *En somme, j'ai adoré enseigner à des élèves de 6ᵉ année à partir d'un robot de téléprésence. Notre présentation s'est très bien déroulée et j'ai beaucoup appris de cette expérience. Si l'occasion se représente, c'est certain que je veux enseigner de nouveau à partir d'un robot de téléprésence* [étudiant(e) 9].

Cette appréciation de la part des étudiantes et des étudiants concerne plusieurs aspects de la relation enseignement-apprentissage. Tout d'abord, ils ont aimé que les élèves soient à l'écoute et étaient motivés par la leçon.

> *J'ai trouvé que les élèves étaient plus motivés à nous écouter, car ils étaient intrigués par le robot donc leur attention était directement sur nous. Si nous avions fait la même expérience, mais en présentiel dans leur classe, je suis certaine que plusieurs n'auraient pas été à l'écoute* [étudiant(e) 6].

Cette nouvelle forme d'enseignement a permis aux étudiantes et aux étudiants de vivre une nouvelle expérience enrichissante. « *J'ai aimé enseigner à partir d'un robot de téléprésence, car ce fut une nouvelle expérience et ça m'a permis de découvrir ce qu'est l'enseignement à distance à travers un robot* » [étudiant(e) 1].

Cette expérimentation avec le robot a également permis aux étudiantes et aux étudiants de mieux connaître la réalité des enseignantes et des enseignants dans un contexte d'enseignement à distance :

> *Enseigner avec l'aide du robot m'a permis de voir la réalité des enseignants lorsqu'ils enseignent à distance. Bref, l'expérimentation m'a donné la chance, en tant que future enseignante, de voir à quoi peut ressembler l'enseignement à distance* [étudiant(e) 8].

Étant donné que les étudiantes et les étudiants sont en début de formation, plusieurs n'ont pas encore eu la chance d'enseigner à des élèves. Pour certains, c'était la première expérience en enseignement auprès des élèves. Le fait d'enseigner à partir d'un robot à distance a probablement été moins intimidant qu'être en présentiel auprès des élèves. « *Parce que c'est moins intimidant que d'aller directement en classe pour la première fois* » [étudiant(e) 15].

Le questionnement concernant leur choix de carrière est toujours présent pour plusieurs étudiantes et étudiants. Les expériences en enseignement auprès des élèves dans les écoles peuvent renforcer leur position à cet effet : « *Ça nous a permis de nous souvenir pourquoi on veut réussir et devenir des enseignants* » [étudiant(e) 13].

Malgré le fait que tous les étudiantes et les étudiants ont apprécié leur expérience et les interactions avec les élèves, il demeure que certains auraient préféré enseigner en présentiel. « *Ce ne serait certainement pas ma méthode préférée. J'aime mieux interagir face à face avec les jeunes* » [étudiant(e) 12].

Interactions avec les élèves

Lorsque l'on enseigne à distance, les interactions entre l'enseignante ou l'enseignant et les élèves demeurent une préoccupation constante pour celui ou celle qui enseigne. Avec l'enseignement à partir d'un robot de téléprésence, il y a lieu de vérifier si ces interactions seront présentes. À cet effet, des étudiantes et des étudiants nous ont indiqué qu'ils ont eu la chance d'interagir avec les élèves. « *Lors de la leçon nous avons interagi avec les élèves à quelques occasions. Les interactions se sont bien déroulées* » [étudiant(e) 9].

Une autre personne étudiante ajoute : « *J'ai aimé que les élèves aient interagi avec nous et qu'ils n'ont pas eu peur de répondre à nos questions. Ils ont été très interactifs donc ceci a mis notre présentation plus agréable et intéressante* » [étudiant(e) 17].

Pour susciter des interactions avec leurs élèves, les enseignantes et les enseignants vont souvent utiliser le questionnement. C'est dans cette perspective que les étudiantes et les étudiants ont posé de nombreuses questions aux élèves lors de leur enseignement :

> *Tout au long de notre présentation, nous posions des questions aux élèves sur la matière que nous enseignions. Par la suite, ceux-ci nous répondaient et nous leur donnions les bonnes réponses. Puis, à la fin, nous avons eu une période de questions où nous avons pu discuter avec eux* [étudiant(e) 9].

Le fait que le robot pouvait se déplacer dans la classe a facilité les interactions avec les élèves. « *Nous pouvions aussi faire bouger le robot (se déplacer pour aller voir les élèves à leur pupitre)* » [étudiant(e) 2].

> *C'était facile de se déplacer avec le robot pour aller voir les élèves qui avaient des questions ou qui voulaient donner une réponse. De cette façon, j'ai senti que les élèves se sentaient écoutés et savaient quand on s'adressait à l'un d'eux spécifiquement* [étudiant(e) 4].

Malheureusement, des difficultés sur le plan technique peuvent à l'occasion diminuer les interactions avec les élèves : « *Les interactions se sont faites avec un peu de difficulté, car le micro du robot n'était pas assez puissant pour capter les voix des élèves. L'enseignante a dû à certains moments répéter l'information pour aider à la compréhension* » [étudiant(e) 7].

Apprentissages effectués

Malgré le fait que les étudiantes et les étudiants ont beaucoup aimé l'expérience en enseignement avec le robot de téléprésence, il y a lieu de se questionner concernant les apprentissages réalisés par ceux-ci. C'est principalement à partir de cette constatation qu'il sera possible de justifier l'utilisation du robot de téléprésence dans le cadre de la formation universitaire des étudiantes et des étudiants en éducation.

Tout d'abord, les étudiantes et les étudiants ont effectué des apprentissages sur la planification de leçons. « *Mon apprentissage sur comment bâtir une mini-leçon* » [étudiant(e) 7].

Cette préparation de leçons peut même devenir très importante afin de diminuer leur stress lors de l'enseignement. « *J'ai appris que c'est très important d'être bien préparé avant d'enseigner parce qu'une bonne préparation peut aider à réduire le stress* » [étudiant(e) 8]. Ils ont également réalisé l'importance qui doit être accordée à la communication pour la réussite de leur enseignement :

> *Cette expérience m'a fait réaliser que la communication est essentielle dans toute situation, mais particulièrement lorsque nous enseignons et que nous sommes à distance. En effet, c'est très important de bien communiquer afin d'éviter toute source de confusion et d'ambiguïté* [étudiant(e) 8].

En plus des apprentissages réalisés en planification et en communication, ils ont réussi à mettre au point des manières de procéder afin de motiver les élèves dans leur apprentissage : « *Oui, j'ai fait des apprentissages pendant la préparation de l'expérience et de l'enseignement. En autres, j'ai appris à trouver des façons pour stimuler les élèves à travers un robot et de garder leur attention* » [étudiant(e) 1].

Durant la préparation de leur leçon, les étudiantes et les étudiants ont appris l'importance de consulter les programmes d'études. Cela leur a permis d'en connaître davantage concernant les résultats d'apprentissage qui doivent être enseignés aux élèves : « *Toucher et voir un programme d'études réel fut très profitable pour nous, puisqu'avec l'aide d'une enseignante, nous avons compris un peu le fonctionnement des RAS et les démarches à prendre* » [étudiant(e) 10].

L'expérimentation a permis de faire prendre conscience aux étudiantes et aux étudiants que la créativité pouvait permettre de surmonter des défis. « *J'ai aussi appris qu'il faut oser sortir des sentiers battus et être créatif lorsque nous sommes confrontés à un défi ou à une situation particulière* » [étudiant(e) 8].

Les étudiantes et les étudiants ont également appris à faire fonctionner le robot et ont pris conscience que celui-ci ne peut pas réaliser toutes les tâches d'un enseignant.

> *En autres, j'ai appris à me servir du robot* [étudiant(e) 1].
>
> *Le robot comporte plusieurs avantages, mais il ne peut pas faire tout le travail d'un enseignant. Par exemple, il aurait été difficile de faire de la discipline dans la classe, puisque nous n'étions pas physiquement présents* [étudiant(e) 9].

Avantages (utilisation du robot)

Les étudiantes et les étudiants ont repéré plusieurs avantages relatifs à l'utilisation d'un robot de téléprésence mobile comme outil technologique pour l'enseignement. Ils ont indiqué que l'effet nouveauté pourrait être une source de motivation pour les élèves : « *En enseignant avec le robot, les élèves voient quelque chose de nouveau et sont portés à vouloir écouter, car c'est différent des méthodes d'apprentissage déjà présentes. Ils n'ont pas la chance d'en avoir un dans leur classe chaque jour* » [étudiant(e) 6].

L'utilisation d'un robot de téléprésence serait meilleure que d'autres outils technologiques dû au fait qu'il peut se déplacer :

> *Le robot de téléprésence permet d'enseigner de la matière à distance, comme les logiciels [plateformes] Teams et Zoom. Cependant, avec le robot, c'est très différent. L'enseignement est plus dynamique, puisque nous pouvons déplacer le robot dans la salle de classe* [étudiant(e) 9].

Un des avantages marquant de l'utilisation du robot de téléprésence est celui de sa pertinence en situation de pandémie alors que l'accès à la salle de classe est très limité ou impossible :

> *Un des avantages les plus importants a des liens directs avec la pandémie que nous vivons en ce moment, car avec les nombreuses restrictions émises par la sécurité publique nous empêchent d'avoir des contacts avec des gens hors de notre bulle. Nous avons quand même eu la chance d'enseigner avec des jeunes et de vivre une expérience semblable a une vraie présentation en salle de classe malgré les conditions actuelles* [étudiant(e) 16].

Il serait même possible d'avoir des conférenciers malgré les restrictions imposées par la pandémie. « *Personne ne peut entrer dans des établissements scolaires, donc si quelqu'un veut venir faire une conférence, il peut faire sa présentation avec le robot* » [étudiant(e) 5].

Une enseignante ou un enseignant peut s'absenter pour différentes raisons. Dans ce cas, il est alors difficile d'avoir une continuité dans les apprentissages. L'utilisation d'un robot pourrait permettre à une enseignante ou un enseignant à distance d'interagir avec ses élèves :

> *L'un des avantages est que si l'enseignant ne peut assister à son cours durant la journée, il peut enseigner aux élèves par l'entremise du robot en se connectant sur celui-ci. Le robot utilisé pour enseigner aux élèves […] peut se déplacer en classe comme l'enseignant et capter l'attention des élèves* [étudiant(e) 2].

Finalement, les étudiantes et les étudiants ont souligné que l'utilisation de cet outil technologique pouvait leur faire vivre des situations authentiques avec des élèves sans se déplacer :

> *Puisque nous ne pouvions pas aller dans les écoles, nous avons quand même eu la chance de voir une réelle situation en salle de classe, mais tout en étant à distance et en utilisant une nouvelle stratégie dont les élèves n'avaient jamais eu la chance de vivre auparavant. Cela nous démontre que nous ne sommes pas toujours obligés de nous déplacer pour vivre des moments authentiques* [étudiant(e) 6].

Désavantages (utilisation du robot)

Les étudiantes et les étudiants ont également relevé des désavantages concernant l'utilisation du robot. Ils ont souligné que cette forme d'enseignement limitait les interactions avec les élèves. « *Ce genre d'enseignement limite les interactions. Les jeunes élèves ont besoin de cette interaction pour partager leurs connaissances et échanger leur point de vue* » [étudiant(e) 10].

Même si le robot peut répondre à plusieurs fonctions en salle de classe, la présence humaine est quand même requise dans certaines situations. « *Il doit toujours avoir quelqu'un avec les élèves afin de* *s'assurer qu'ils sont attentifs à ce qui se passe et de dire aux élèves de rester en silence parce que le volume n'est pas fort* » [étudiant(e) 5].

Étant donné que le robot ne peut pas écrire au tableau, l'utilisation du robot limite les démonstrations sur le plan visuel. « *L'enseignement avec un robot de téléprésence limite les démonstrations visuelles, qui pour certains, sont primordiales à leur compréhension* » [étudiant(e) 10].

Comme mentionné précédemment, le robot peut être une source de motivation étant donné la nouveauté de cette approche. À l'inverse, cette façon de faire pourrait devenir une source de distraction pour les élèves. « *Cela peut aussi être une source de distraction pour les élèves, car ils vont être intrigués par le robot et son déplacement et n'écouteront plus le professeur qui parle* » [étudiant(e) 2].

Finalement, diverses difficultés sur le plan technique peuvent causer des problèmes dans l'enseignement.

> *Lorsque je parlais, la connexion a lâché. Donc, la connexion n'est pas fiable à 100 %* » [étudiant(e) 3].
>
> *Un autre désavantage est que l'on ne voit pas bien les élèves dans la classe. Il peut être difficile de les discerner lorsque le robot n'est pas proche. On ne peut pas voir l'ensemble de la classe en même temps afin de voir les interactions des élèves et être à l'écoute des gestes ou signes de chacun* [étudiant(e) 1].

Amélioration de l'expérience (apprentissage des élèves)

Les étudiantes et les étudiants ont beaucoup aimé enseigner avec le robot et ils ont effectué des apprentissages dans différents domaines. Cette expérience fut donc très positive. Cependant, il y a quand même lieu de se questionner sur les éléments à améliorer concernant les expériences effectuées à partir du robot de téléprésence mobile.

Tout d'abord, les étudiantes et les étudiants ont souligné des éléments qui sont reliés aux apprentissages des élèves. Ils ont mentionné que de présenter le robot aux élèves au préalable aurait permis de diminuer l'agitation des élèves : « *Je crois que simplement leur présenter le robot rapidement avant de l'utiliser leur permettait de mieux garder leur attention sur la matière enseignée puisqu'ils savent déjà à quoi s'attendre* » [étudiant(e) 4]. Ils ont également souligné l'importance de préparer le matériel à l'avance : « *Je demanderais à l'enseignant de préparer le matériel avant de commencer ma présentation afin de ne pas les exciter et de ne pas perdre le contrôle sur leur attention* » [étudiant(e) 6].

Pour cette première expérience dans les écoles pour plusieurs étudiantes et étudiants, ils devaient préparer des leçons de courte durée. Il a été souligné qu'ils auraient aimé avoir plus de temps avec les élèves afin d'assurer la participation de tous :

> *Je crois que l'expérience aurait pu être d'une plus longue durée afin que tous les élèves aient la chance de venir parler au robot, puisque pour eux, c'était un grand évènement et très excitant. Je crois qu'ils auraient tous aimé avoir la chance de parler au robot* [étudiant(e) 10].

Dans le but d'améliorer l'expérience vécue par les élèves, il aurait été possible de déplacer davantage le robot :

> *Un aspect que nous pourrions modifier afin d'améliorer la situation d'apprentissage vécue par les élèves est sans aucun doute de faire bouger le robot davantage. Par exemple, lorsqu'un élève a une question, nous pourrions déplacer le robot à son pupitre. Selon moi, plus le robot imitera le comportement d'un enseignant, c'est-à-dire se déplacer en salle de classe, plus l'enseignement sera intéressant et dynamique pour les élèves. En d'autres mots, ces derniers n'auront pas l'impression de parler à un ordinateur, mais bien à une personne qui se trouve tout simplement à distance* [étudiant(e) 8].

Finalement, les étudiantes et les étudiants ont mentionné qu'il aurait fallu faire participer davantage les élèves afin de maintenir l'attention des élèves. « *Faire participer les élèves le plus possible afin de pouvoir garder leur attention sur la présentation* » [étudiant(e) 6].

Amélioration de l'expérience (expérience étudiante)

En plus des éléments pouvant améliorer les apprentissages des élèves, les étudiantes et les étudiants ont proposé des éléments pouvant améliorer l'expérience étudiante. Ils ont souligné qu'avoir plus de temps de préparation aurait été bénéfique :

> *Dans mon cas, j'aurais bien aimé avoir plus de temps de préparation. Je sais très bien que c'était hors de notre contrôle cette fois-ci, mais dans le futur, je crois que ça serait bien si les étudiants avaient plus de temps pour se préparer* [étudiant(e) 8].

Les étudiantes et les étudiants recommandent également que les matières d'enseignement choisies pour les leçons soient reliées à leurs champs d'intérêt. « *De plus, le sujet de matière était hors de mon champ de confort et cela m'a causé un stress de plus* » [étudiant(e) 14].

Étant donné qu'il s'agissait des premières expériences en enseignement des étudiantes et étudiants et que ceux-ci sont en début de formation, toutes les compétences concernant la planification de leçons n'ont pas encore été acquises. « *J'aurais peut-être aimé apprendre à faire une leçon plutôt que de juste présenter comme une présentation orale normale* » [étudiant(e) 13].

Les étudiantes et les étudiants ont soulevé le fait qu'ils auraient aimé recevoir une formation au préalable concernant le fonctionnement du robot. « *Offrir une meilleure formation avec le robot serait nécessaire, ce qui permettrait ainsi aux présentateurs de mieux partager le contenu* » [étudiant(e) 7].

De plus, ils auraient aimé utiliser et faire fonctionner le robot avant d'enseigner avec celui-ci. « *Selon moi, nous devrions peut-être manipuler le robot plus souvent avant d'aller en salle de classe, car nous n'étions pas très habiles lors des déplacements* » [étudiant(e) 6].

Finalement, plusieurs étudiantes et étudiants ont indiqué qu'ils ne changeraient rien à cette expérimentation avec le robot. « *Je crois que rien ne devrait être changé car c'était une expérience très unique et amusante pour les élèves et aussi pour nous* » [étudiant(e) 11].

> *Je ne pense pas que changer quelque chose soit nécessaire. À mon avis, cette expérience s'est très bien déroulée, nous n'avons eu aucune difficulté avec les élèves et les professeurs n'ont pas eu besoin d'interagir. Je suis convaincu que dans le cadre des cours d'éducation ce genre d'expérience devrait être utilisé beaucoup plus souvent* [étudiant(e) 5].

Discussion

Le point central de cette expérimentation concerne les apprentissages effectués par les étudiantes et les étudiants en éducation. Les résultats montrent clairement que l'utilisation du robot de téléprésence a permis de parachever l'enseignement théorique du cours universitaire. Ceci représente d'ailleurs la raison d'être des expériences pratiques dans le système scolaire. L'utilisation du robot a permis aux étudiantes et aux étudiants de vivre une expérience authentique et d'effectuer des apprentissages sur l'importance de la planification et de la communication, sur la connaissance des programmes d'études ou sur la façon de motiver les élèves lors des leçons.

Les résultats de recherche ont également montré qu'il fut possible d'interagir avec les élèves lors de l'expérimentation avec le robot. Ces interactions furent rendues possibles grâce aux questions posées aux élèves, et surtout, par le déplacement du robot. À cet effet, des recherches (Dussarps et al., 2020; Poyet et al., 2018) soulignent que la mobilité du robot favorise les interactions entre les participantes et les participants. Ces robots de téléprésence furent d'ailleurs conçus pour atteindre cet objectif, soit de permettre des déplacements (Batmaz et al., 2020). Cette méthode d'enseignement est plus interactive que la rencontre en vidéoconférence où la caméra est fixe (Verchier et al., 2023). Comme l'indiquent Verchier et ses collaborateurs (2023), « l'utilisateur qui est à distance pilote le robot et peut donc être acteur de la session à laquelle il participe » (p. 224).

Le principal avantage de l'utilisation du robot est sa mobilité, soit le fait que celui-ci puisse se déplacer comparativement à d'autres plateformes de vidéoconférence qui ne sont pas mobiles (Gallon & Abenia, 2018). Celles-ci peuvent agrandir ou diminuer l'image, mais le robot, lui, peut se déplacer, ce qui représente un avantage pour interagir avec une personne qui se trouve par exemple en arrière dans une classe (Petit et al., 2020). Comme le soulignent Verchier et ses collaborateurs (2023), « les interfaces comme Zoom ou Teams montrent leurs limites en face à face écran […] c'est-à-dire que l'on constate un manque de mobilisation des sens, comme cela se fait naturellement en présentiel » (p. 223). Cependant, si l'on combine les avantages des plateformes de vidéoconférence qui ne sont pas mobiles (la facilité d'utilisation, la possibilité de partager des documents et la possibilité d'écrire des messages) avec l'avantage principal du robot de téléprésence (la possibilité de déplacement du robot), cette complémentarité représente une perspective très intéressante pour l'enseignement à distance.

Notons également que les étudiantes et les étudiants ont pris plaisir à cette expérience novatrice dans le système scolaire en raison de la motivation des élèves lors de la leçon. Cette motivation peut s'expliquer en partie par l'effet de nouveauté que représente le robot (Poyet et al., 2018).

Les résultats de recherche ont également montré que des problèmes techniques peuvent survenir lors des expériences avec le robot de téléprésence (Poyet et al., 2018). Il faut donc accorder une importance à la préparation technologique avant d'utiliser des robots de téléprésence dans les écoles. À cet effet, il est essentiel qu'une technicienne ou un technicien en informatique fasse au préalable des vérifications de compatibilité entre le robot et les pare-feux présents dans les écoles, car il est possible que des ajustements doivent être apportés afin que le robot soit fonctionnel. À la suite de ces vérifications et ajustements, il est important que les étudiantes et les étudiants fassent des tests à distance pour vérifier la fonctionnalité du robot (la qualité du son, la qualité de l'image, la connexion, le déplacement du robot, etc.).

Conclusion

Le but de l'expérimentation était d'étudier l'enseignement à distance par le biais d'un robot de téléprésence mobile et d'examiner sa contribution à la formation des étudiantes et des étudiants. C'est dans cette perspective que les étudiantes et les étudiants ont constaté l'importance d'une bonne préparation, ont interagi avec des élèves et ont pris conscience du rôle de la motivation dans l'apprentissage. Les expériences pratiques permettent donc de suppléer au manque d'interrelation entre la théorie et la pratique. En ce qui a trait à l'utilisation des technologies dans le milieu de l'éducation, la réflexion doit se poursuivre. Comme l'indique Verchier et ses collaborateurs (2023), « au-delà de la technologie utilisée, il nous semble important, dans le champ de la formation tant initiale que continue, de nous interroger sur les intentions pédagogiques associées à l'utilisation de ces différents outils » (p. 224), et ce, tel qu'il fut le cas dans cette recherche.

Malgré les nombreux bénéfices énumérés, cette étude a comme limite le nombre total d'expériences en salle de classe (11 classes) et le ratio école primaire/école secondaire (cinq écoles primaires par rapport à deux écoles secondaires). Étant donné l'aspect très novateur de cette recherche, d'autres expériences sont nécessaires afin de valider les résultats. À cet effet, les divers éléments proposés dans la section « amélioration des apprentissages (élèves) » et la section « amélioration (expérience étudiante) » seront certainement utiles dans le cadre de nouvelles recherches. Les besoins concernant l'enseignement à distance vont continuer à augmenter (Bates et al., 2018; Petit et al., 2020), d'où l'importance pour les programmes de formation en éducation d'offrir des expériences diversifiées (comme celle avec le robot) qui vont permettre de bien préparer les étudiantes et les étudiants à l'environnement pédagogique du futur (Cirillo et al., 2020).

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Effects of Robotic Coding on Computational Thinking Skills of Secondary School Students

Effets du codage robotique sur les compétences de pensée computationnelle des élèves du secondaire

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Abstract

In recent years, computational thinking has garnered increased attention as an essential problem-solving skill. One of the methods to develop students' computational thinking skills is robotic coding activities. This study sought to investigate the impact of robotic coding activities on the self-efficacy perceptions of secondary school students' computational thinking skills. A one-group pretest-posttest quasi-experimental design was employed, involving 32 secondary school students. These students, organized in groups of four, engaged in hands-on robotic coding activities using Lego Mindstorms EV3 Education robots over a total of 20 hours. Data were collected before and after the robotic coding activities using the Self-Efficacy Perception Scale for Computational Thinking Skills (SEPSCTS) instrument, comprising 36 items categorized into five factors. The data were analyzed using paired samples *t*-tests and analysis of covariance (ANCOVA). The results demonstrated a significant increase in students' self-efficacy perceptions of computational thinking skills following the activities, with this increase observed consistently across genders. Finally, the challenges encountered during research and practice were reported, along with the study's limitations, to inform future research endeavours.

Keywords: computational thinking, perception, robotic coding, self-efficacy

Résumé

Ces dernières années, la pensée computationnelle a fait l'objet d'une attention accrue en tant que compétence essentielle pour la résolution de problèmes. L'une des méthodes pour développer les compétences des élèves en matière de pensée computationnelle est le codage robotique. Cette étude visait à examiner l'impact des activités de codage robotique sur les perceptions d'auto-efficacité des compétences de pensée computationnelle des élèves du secondaire. Un modèle quasi expérimental prétest-post-test à groupe unique a été utilisé, impliquant 32 élèves du secondaire. Ces élèves, organisés en groupes de quatre, ont participé à des activités pratiques de codage robotique en utilisant des robots *Lego Mindstorms EV3 Education* pendant un total de 20 heures. Les données ont été collectées avant et après les activités de codage robotique à l'aide de l'instrument *Self-Efficacy Perception Scale for Computational Thinking Skills* (SEPSCTS pour ses sigles en anglais), qui comprend 36 éléments répartis en cinq facteurs. Les données ont été analysées à l'aide de tests t pour échantillons appariés et d'analyses de covariance (ANCOVA). Les résultats ont démontré une augmentation significative des perceptions d'auto-efficacité des élèves en matière de compétences de pensée computationnelle à la suite des activités, cette augmentation étant observée de manière cohérente entre les genres. Finalement, les défis rencontrés au cours de la recherche et de la pratique ont été rapportés, ainsi que les limites de l'étude, afin d'informer les recherches futures.

Mots-clés: pensée computationnelle, perception, codage robotique, auto-efficacité

Introduction

Computational Thinking

Computational thinking was pioneered by Papert (1980) who suggested that individuals must be taught essential thinking skills related to programming, and by Perlis (1962) who highlighted the importance of computer technology in solving real-life problems with its structure and operational logic. Computational thinking is defined as "problem-solving, system designing, and understanding human behaviour using the concepts of computer science" (Wing, 2006, p. 33). However, Sysło and Kwiatkowska (2013) argued that the focus should be on thinking skills based on the principles of programming and the systematic solution of problems rather than just programming skills for solutions, designs, and gains as emphasized in the general definition offered by Wing (2006). Similarly, the International Society for Technology in Education (ISTE) suggested that instead of teaching specific skills in the field of informatics, individuals should be encouraged to adopt the habit of applying this skill, which reflects algorithmic, creative, critical thinking, and problem-solving skills, in every area of life. In this regard, a joint study conducted by ISTE in collaboration with the Computer Science Teachers Association (CSTA) in 2011 defined the wordnet related to the concept of computational thinking to include the following components: data collection, analysis, representation, decomposition, abstraction, algorithms and procedures, automation, simulation, and parallelization.

When examining frequently cited publications in the literature, it becomes evident that the fundamental concepts of the computational thinking process are categorized in various ways. Computational thinking encompasses a set of key concepts and steps that are essential for problem-solving and system design in the field of computer science. These concepts have been classified by various researchers in the literature. According to Wing (2006; 2008; 2011), the key concepts include problem decomposition, abstraction, algorithms, automation, and generalization. Barr and Stephenson (2011) categorized them as abstraction, algorithms and procedures, automation, problem decomposition, parallelization (parallel processing), and simulation. Lee et al. (2011) emphasized abstraction, automation, and analysis. Selby and Woollard (2013) identified abstraction, algorithms or algorithmic thinking, problem decomposition, evaluation, and generalization as key components. Lastly, Angeli et al. (2016) outlined abstraction, algorithms or algorithmic thinking, problem decomposition, debugging, and generalization as fundamental elements of computational thinking.

It is not surprising that the basic concepts are perceived and classified differently depending on the experiences of practice-based researchers. However, most studies tend to refer to Wing's (2008) classification, which was then adapted to practice and transformed into a framework that includes the following basic steps:

1. **Problem decomposition**: the process of breaking down a problem into smaller, more manageable parts to facilitate a more efficient solution.
2. **Abstraction**: the prioritization and classification of solution methods and necessary information, based on their significance (inclusion and exclusion), and the conceptualization of solution approaches.
3. **Algorithm (algorithmic thinking)**: the design and planning of the necessary steps to effectively and efficiently resolve a problem.
4. **Automation (automatization)**: the technological structuring of algorithms, enabling them to be applied autonomously and limitlessly within their respective contexts.
5. **Generalization (generalizing)**: the adaptation of the technological solutions generated to make them applicable or feasible for addressing other similar or different problems.

(pp. 3717–3719)

When examined comprehensively in terms of both concept and process, computational thinking distinguishes itself from problem-solving skills, to which it closely relates, in several significant ways (ISTE & CSTA, 2011). First, it involves the structuring of solutions to problems from a technology-oriented perspective. It emphasizes not only the hierarchical nature of problems and sub-problems but also the analysis of patterns and the recognition of similarities among them. Additionally, it assesses the suitability and, ideally, the efficiency of the methods and sources of solutions. Furthermore, computational thinking encompasses the capacity to automate technological solutions for similar problems and to transfer and generalize these solutions to address diverse problem domains. In this regard, improving computational thinking cannot be achieved solely through efforts to enhance problem-solving skills; such efforts would yield limited results. Therefore, as described in the literature, there are specialized activities and practices designed to enhance computational thinking skills, along with numerous strategies and methods that can be employed in these learning environments.

In the literature review conducted by Berikan (2018), strategies and methods currently employed or recommended for improving computational thinking skills include project-based learning (Bower et al., 2017), product-based learning (Brennan & Resnick, 2012), questioning and discussion strategies (ISTE & CSTA, 2011), and problem-based learning (Mingo, 2013). Similarly, Gülbahar et al. (2019) reported the use of computer games (Apostolellis et al., 2014), simulations (Basawapatna et al., 2013), unplugged activities (Curzon et al., 2014), and traditional programming activities for enhancing computational thinking skills. Additionally, the literature encompasses the use of mobile programming activities (Morelli et al., 2011), course processes (Israel et al., 2015; Rubinstein & Chor, 2014), and curriculum designs (Bers et al., 2014) to foster computational thinking skills.

In addition to the aforementioned strategies, methods, and activities designed to enhance computational thinking skills, it is possible that alternative approaches have not yet been explored. Ackermann (2001) points out that all strategies, methods, or activities related to the development of computational thinking skills, whether studied or not, are based on Piaget's constructivism and Papert's constructionist theory. In their literature review study, Lye and Koh (2014) examined 27 studies focused on the development of computational thinking skills at the K–12 level and found that these studies were grounded in these theories.

Built upon the principles of learning-by-doing and problem-solving in real-life contexts, these theories serve as the foundation for the assertion made by Hsu et al. (2018) that many educators consider programming to be the most direct and effective method for teaching computational thinking skills, as it encourages independent problem-solving. Consequently, traditional programming, unplugged programming activities, and contemporary approaches like robotics and physical programming are steadily gaining popularity in the quest to develop computational thinking skills.

Robotic Coding

The use of robotics in education can be categorized into three primary tendencies: robotics as learning objectives, robotics as learning aids, and robotics as learning tools (Eguchi, 2012). In contrast, Sullivan and Heffernan (2016) classified the use of robotics in education into "first-order uses" and "second-order uses" (p. 3). They proposed that robots could serve as a means for direct instruction in robotics (first-order uses) or as analogical tools for teaching in other academic domains (second-order uses). Educational robots, defined as robots used as learning tools within classroom settings, fall into this category (Eguchi, 2017).

The history of educational robots traces back to the pioneering work of Seymour Papert, the creator of the Logo programming language and the proponent of constructionist theory (Papert, 1993). Constructionism is founded on the principle that learning takes place when individuals actively construct a meaningful product (Harel & Papert, 1991). In fact, Harel and Papert provided the simplest definition for constructionism as "learning by making" (para. 1). In this context, constructionism shares similarities with the constructivist approach, viewing knowledge as a personal experience to be constructed rather than a commodity to be transmitted, encoded, stored, and reused (Ackermann, 2001).

Robotic activities assist students in constructing new knowledge if the pedagogical process is also engaging active learners to collaborate with their peers and adopt the role of researchers (Atmatzidou & Demetriadis, 2016). The hands-on nature of educational robots, which allows students to learn through practical experience, fosters an engaging and stimulating educational environment by seamlessly integrating technology into the subject matter (Eguchi, 2017). Furthermore, educational robotics offers students an opportunity to work collaboratively (Alimisis, 2013; Bers, 2008), providing a tangible means of comprehending abstract concepts and ideas (Bers, 2008). For example, an educational robot operating under the same program will exhibit different movements on smooth surfaces like parquet floors compared to uneven surfaces like carpets, due to variations in frictional forces generated by the surfaces. This immediate feedback from the educational robot renders abstract concepts visible and facilitates students' grasp of these concepts (Eguchi, 2016).

From a programming perspective, the physical nature of educational robots offers students immediate and tangible feedback on the efficiency of the algorithms they have written (Eguchi, 2012; Sullivan & Heffernan, 2016). Educational robotics kits enable even beginners to program complex robotic behaviours using the graphical programming environments. As a result, educational robotics kits can be effectively used with young learners. Moreover, the literature features several studies conducted with kindergarteners on robotic coding (Bers et al., 2014; Chalmers, 2018; Kazakoff et al., 2013).

In summary, educational robotics kits are frequently used to achieve various objectives, including the development of programming skills (Atmatzidou et al., 2008; Baek et al., 2019), enhancement of problem-solving abilities (Nugent et al., 2016; Witherspoon et al., 2017), and the teaching of cooperative learning skills (Eguchi, 2014a; Mitnik et al., 2008). Furthermore, there is a body of research demonstrating that educational robotics can also contribute to the development of computational thinking skills (Atmatzidou & Demetriadis, 2016; Bers et al., 2014; Constantinou & Ioannou, 2018; Leonard et al., 2016; Noh & Lee, 2020).

Robotic Coding and Computational Thinking

Educational robotics is recognized as an effective tool for enhancing students' computational thinking skills (Baek et al., 2019; Chalmers, 2018; Eguchi, 2014b, 2016) because students must consider the robot design and behaviour programming that will best interact with the physical world within the context of a given situation or problem. During this process of generating solutions, participants first thoroughly analyze the problem and the constraints of the real world. Then, based on their findings and the educational robot's capabilities, including its perception of the real world and the responses to stimuli encoded in the program, they assess the program's numeric and decision-making values. If the educational robot exhibits unexpected behaviour, it may indicate flaws in the implementation of ideas or conditions encountered that were either overlooked or misjudged during the abstraction phase (Lee et al., 2011). Once the coded program operates successfully on the robot, automation is achieved.

It is acknowledged that the number of experimental studies investigating the impact of robotic coding on students' computational thinking skills is limited (Berland & Wilensky, 2015; Ioannou & Makridou, 2018). Notably, the literature highlights a scarcity of studies conducted at the K–12 level, indicating insufficiency in this area (Constantinou & Ioannou, 2018; Witherspoon et al., 2017). Recognizing this gap, the present study aims to explore the effect of robotic coding activities on secondary school students' self-efficacy perceptions of computational thinking skills and whether any significant gender-based differences exist. The following research questions guided this study:

1) How do robotic coding activities influence the self-efficacy perceptions of secondary school students regarding computational thinking skills?

2) Are there any gender-based differences in the impact of robotic coding activities on the self-efficacy perceptions of secondary school students regarding computational thinking skills?

Method

Research Design

In this study, which investigated secondary school students' self-efficacy perceptions of computational thinking skills, a one-group pretest-posttest quasi-experimental design was employed. This design, aligned with the quantitative research approach, facilitates the repeated analysis of numerical data using statistical methods and is frequently used to examine causality through comparisons or deductions in educational settings where it is not possible to exert full control over variables (Büyüköztürk et al., 2017; Cohen et al., 2017). A one-group pretest-posttest quasi-experimental design involves obtaining measurements or observations related to a single group by administering the same measurement instrument at different points in time (before and after implementation; Fraenkel et al., 2011; McMillan & Schumacher, 2013).

Participants

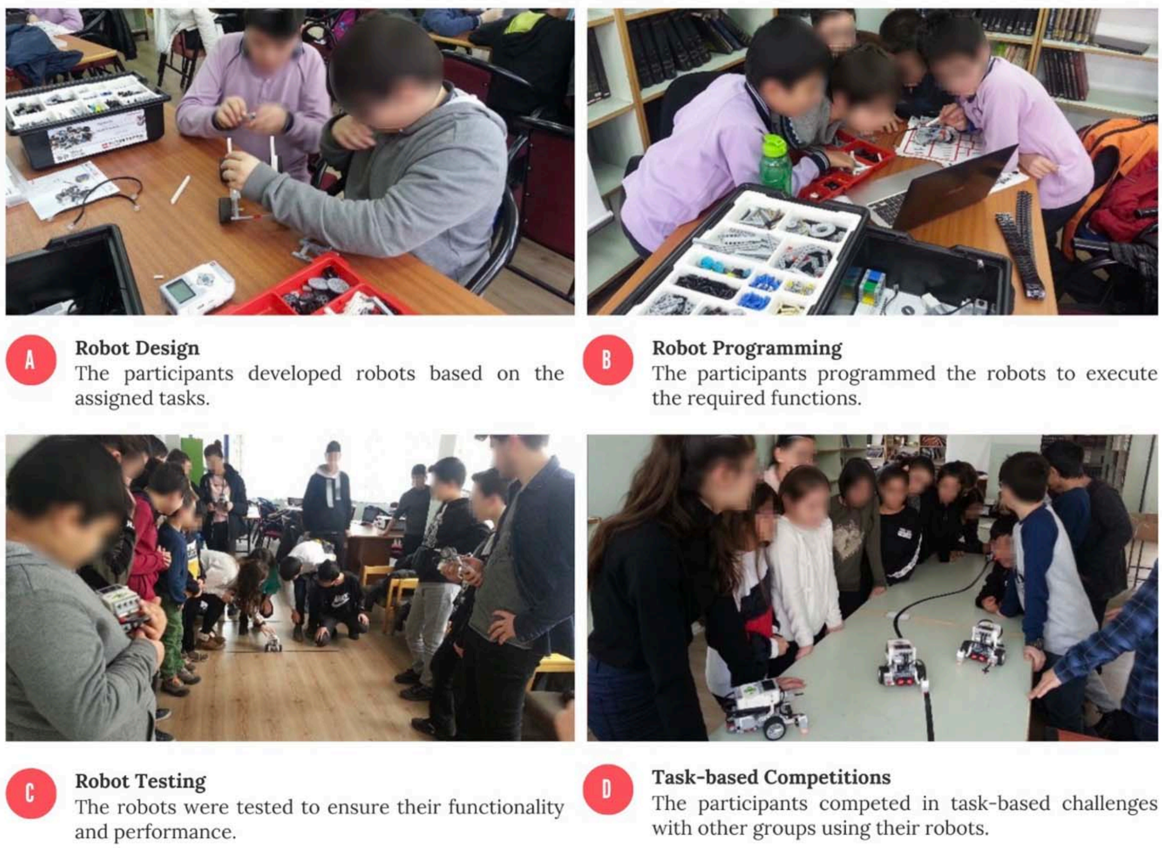
The study comprised a cohort of 32 students (17 males and 15 females) enrolled in a public secondary school in Turkey. The secondary school level consists of 5^{th}, 6^{th}, 7^{th}, and 8^{th} grade levels. Participant selection for the robotic coding activities, conducted outside of regular school hours, was facilitated by the school administration, drawing from a pool of volunteers. Initially, 40 students enrolled in these activities, however, 8 students were subsequently excluded from the study for various reasons, including discrepancies in the use of aliases between the pretest and posttest, as well as non-participation in the posttest assessment. Consequently, data from 32 students (20 in the sixth grade and 12 in the eighth grade) were considered for analysis. Participants were further categorized based on their grade levels, resulting in 9 males and 11 females in the sixth grade, and 8 males and 4 females in the eighth grade.

Robotic Coding Activities

Group activities involving Lego Mindstorms EV3 Education robots and expansion kits were conducted in the school library, which was physically designed to facilitate these activities. Due to space constraints and a limited number of robotic kits available (n=5), separate sessions were organized for sixth and eighth grades. The participants engaged in a robotics curriculum delivered over a five-week period, comprising a total of 20 instructional hours. This curriculum was implemented through weekly sessions, each lasting four hours. Figure 1 shows a selection of photographs captured during the robotic coding activities.

Figure 1

Images of Robotic Coding Activities



Note. Images illustrate the stages of the robotic coding activities. Panel A: Participants constructed robots based on the tasks. Panel B: Participants programmed the robots to execute the specified functions. Panel C: The robots were tested to ensure that the components designed for the task worked. Panel D: Competitions utilizing their robots to address specific task-oriented challenges.

Students were organized into groups of four, with each group assigned an experienced senior university student as a mentor. Mentors received training on Lego Mindstorms EV3 robotic kits and had worked on various projects. Mentors provided guidance to their respective student groups to assist them in completing the assigned tasks. It’s important to note that the mentors did not provide direct solutions to the problems; rather, they offered the students support when needed.

Lego Mindstorms, one of the most widely used kits in the field of robotics (Benitti & Spolaôr, 2017), was employed for these activities. Specifically, the Lego Mindstorms EV3 Education robotic kit, designed specifically for educational purposes (Afari & Khine, 2017), was used. The sets include a programmable smart brick that serves as a compact computer, controlling the motors and collecting data from sensors. It also consists of three servo motors, seven data cables, one USB cable, a rechargeable battery, as well as gears, treads, wheels, axles, and other technical components[1]. The EV3 programming software features a user-friendly drag-and-drop graphics interface, enabling students to concentrate on computational concepts rather than the syntax of programming languages (Ching et al., 2018). Additionally, the software offers the capability to visualize graphs of data collected from sensors through its experiment interface.

Students received hands-on instruction on robot programming and operation using the Lego Mindstorms kit, including guidance on configuring robot movements, using screen and sound functions, understanding and using sensors such as ultrasonic, color, touch, and gyroscope sensors, performing arithmetic and logical operations, logging data, and creating graphic representations. To engage student motivation, several games and competitions were incorporated into the activities. The final day of the program was dedicated to robotics projects, during which each group independently designed and programmed their robots to address real-life problems, such as creating an electronic cane. Sample two-hour activity plans are presented in the Appendix. The aims of the activities were as follows:

- to trigger students' creativity by enabling them to develop their own robots,
- to develop critical thinking and problem-solving skills by presenting unstructured problems,
- to develop students' social skills, communication and co-operation skills, and leadership and responsibility skills by directing them to group work,
- to develop critical thinking and problem-solving skills by programming robots for specific purposes,
- to create a student-centred learning environment where real-life problems are presented during the activities and to direct students to multidimensional and interdisciplinary thinking, and
- to trigger students' curiosity, research, and learning desires with a learning environment where robots can be developed in an unlimited way.

Instruments

The study used the Self-Efficacy Perception Scale for Computational Thinking Skills (SEPSCTS), which was developed by Gülbahar and colleagues in 2019. This scale consists of 36 items categorized into five factors. The reliability coefficients associated with the various factors of the scale fall within the range of .762 to .930, with an impressive overall reliability coefficient of .943 (Table 1). The researchers affirm that this scale serves as a suitable and dependable instrument for assessing the perceptions of self-efficacy in computational thinking skills among students aged 10 to 14 years.

[1] http://education.lego.com

Table 1

Items and Reliability Coefficients of SEPSCTS Factors

Factor	Items *n*	Cronbach's alpha (α) coefficient
Algorithm design competency	9	.930
Problem-solving competency	10	.880
Data-processing competency	7	.856
Basic programming competency	5	.838
Self-confidence competency	5	.762
Overall	36	.943

Data Collection and Analysis

The SEPSCTS was applied to all participants both before and after the robotic coding activities. An equal number of pretest and posttest questionnaires were analyzed to determine the appropriate statistical technique for the study. Data collected were processed using IBM SPSS Statistics (Version 23), and skewness and kurtosis values were examined to assess normality violations. According to George and Mallery (2019), skewness and kurtosis values within the range of ±1 are considered ideal, while values within the range of ±2 are considered normal for various psychometric purposes. In this study, the skewness and kurtosis values were found to be within the range of ±2 for only two of the sub-scales, and within the range of ±1 overall. Consequently, parametric tests were chosen for the quantitative data analysis. To compare students' self-efficacy perceptions for computational thinking skills before and after the activities, a paired samples *t*-test was employed. Additionally, to investigate potential differences in students' self-efficacy perceptions based on gender, one-way covariance analysis (ANCOVA) was used (Pedhazur & Schmelkin, 2013).

Results

Self-Efficacy Perceptions of Computational Thinking Skills

The significance levels of the *t*-test, as well as the means and standard deviations of the pretest and posttest data collected through the scale to assess the impact of robotic coding activities on the self-efficacy perceptions of secondary students regarding computational thinking skills, are detailed in Table 2.

Prior to the activities, students exhibited the lowest mean scores on the basic programming competency subscale and the highest mean scores on the problem-solving competency subscale. After the activities, the students continued to have the lowest mean scores on the basic programming competency subscale, but they now had the highest mean scores on the algorithm design competency subscale, surpassing their previous high in problem-solving competency. According to the paired-samples *t*-test results, the students' self-efficacy perceptions significantly increased in all sub-dimensions and the total self-efficacy scores of the scale ($p < .05$). Cohen's *d* effect sizes were calculated for all sub-dimensions and total SEPSCTS scores to assess the magnitude of the changes between the pretest and posttest. The results indicate a medium-effect size for problem-solving and self-confidence competencies and a large-effect size for the total SEPSCTS, algorithm design, data processing, and basic programming competencies. Based on these findings, it was concluded that the robotic coding activities conducted with secondary school students had a positive effect on their self-efficacy perception of computational thinking skills.

Table 2

Results of the t-*Test for Self-Efficacy Perceptions in Computational Thinking Skills*

Factor	Pretest		Posttest		*t*(31)	*p*	Cohen's *d*
	M	*SD*	*M*	*SD*			
Algorithm design competency	2.01	0.44	2.70	0.30	7.79	.000*	1.38
Problem-solving competency	2.45	0.27	2.60	0.30	2.45	.020*	0.43
Data-processing competency	2.26	0.41	2.63	0.34	5.14	.000*	0.91
Basic programming competency	1.83	0.57	2.39	0.45	5.07	.000*	0.90
Self-confidence competency	2.38	0.43	2.61	0.30	2.38	.024*	0.42
Total self-efficacy perception	2.20	0.30	2.61	0.26	6.50	.000*	1.15

Note. N=32. *p < .05.

Gender Differences

Assumptions were assessed before the ANCOVA, and it was observed that the assumptions were satisfied concerning the normal distribution of the dependent variable, homogeneity of variance (Levene's test), and equivalence of regression line slopes. A summary of posttest scores on SEPSCTS when adjusted for pretest scores of SEPSCTS (the covariate) for both male and female students, reveal no statistically significant differences in total scores or across all factors (Table 3). In other words, the positive impact of robotic coding activities on the self-efficacy perceptions of secondary school students regarding computational thinking skills was consistent regardless of gender.

Table 3

ANCOVA Results for SEPSCTS by Gender

Factor	Gender	*n*	Posttest *M*	Posttest *SD*	*F*(1, 29)	*p*	partial η^2
Algorithm design competency	Male	17	2.73	0.24	0.37	.547	0.47
	Female	15	2.67	0.36			
Problem-solving competency	Male	17	2.57	0.34	0.50	.487	0.21
	Female	15	2.63	3.36			
Data-processing competency	Male	17	2.67	0.28	1.80	.190	0.21
	Female	15	2.60	0.41			
Basic programming competency	Male	17	2.51	0.42	2.33	.138	0.57
	Female	15	2.27	0.46			
Self-confidence competency	Male	17	2.60	0.31	0.09	.766	0.14
	Female	15	2.62	0.29			
Total self-efficacy perception	Male	17	2.62	0.22	0.33	.572	0.15
	Female	15	2.58	0.31			

Discussion

Although computational thinking skills may initially seem to be primarily associated with the fields of engineering and science, Furber (2012) argued that these skills are essential for anyone aspiring to lead a high-quality life. However, computational thinking sets itself apart from other competencies that are expected from individuals, such as problem-solving, product development, project work, and finding solutions, due to its distinct technological efficiency perspective. From this viewpoint, it is suggested that the use of computational tools can lead to more effective and efficient problem-solving outcomes (Cuny et al., 2010, as cited in Wing, 2010). Therefore, it is believed that analyzing problems within this computational context, classifying them, and synthesizing the findings can yield generalizable solutions (ISTE & CSTA, 2011).

Wing (2008) asserted that the development of computational thinking skills can commence as early as preschool, while Barr and Stephenson (2011) argued it is more suitable to introduce these activities in secondary school, aligning with Piaget's (1936) formal operational stage (typically beginning at age 11). Given that study participants were students in the sixth and eighth grades, the choice aligns with the varying expert opinions found in the literature. It is noteworthy that the methods and approaches selected for educational activities aimed at enhancing computational thinking skills are just as crucial as determining the appropriate starting level for these activities.

The SEPSCTS instrument, used in this research, has five sub-dimensions: algorithm design, problem-solving, data processing, basic programming, and self-confidence competencies. The findings revealed that students demonstrated significant improvements across these key competencies, indicating that students' self-efficacy perceptions in computational thinking were enhanced as a result of participating in the robotic coding activities.

Algorithm Design

Algorithmic thinking is a key component of computational thinking, and engaging in robotics coding helps students grasp and apply algorithmic thinking by creating step-by-step instructions for their robots (Grover & Pea, 2018). This study demonstrated significant improvement in students' algorithm design skills after 20 hours of engagement with educational robotics activities. The related literature showed that the development of algorithmic thinking can begin at a young age with suitable, simpler tasks (Ching & Hsu, 2024). Robotics activities provide young learners with a hands-on approach to developing algorithmic thinking through tangible robots, interactive exercises, and real-time feedback, supporting earlier research on fostering these skills in young children (Futschek & Moschitz, 2011). This study's demonstration of enhanced algorithmic thinking skills mirrors the conclusions drawn in similar studies across the literature, such as Yilmaz Ince and Koc's (2021) study on robotics programming education. However, Atmatzidou and Demetriadis (2014) reported that most students had difficulty describing the algorithm in a clear and accurate manner in their study with educational robotic activities used for secondary school students.

Problem-Solving

Computational thinking involves problem-solving (Wing, 2006), and is identified as one of its core concepts (Yadav et al., 2016). The findings of the study revealed that the students' problem-solving competencies, as measured by the SEPSCTS, had significantly improved by the end of the intervention. Many studies report that robotic activities had positive effects on problem-solving skills (Atmatzidou & Demetriadis, 2014; Blanchard et al., 2010; Constantinou & Ioannou, 2018; Eguchi, 2014b; Karp & Maloney, 2013; Petre & Price, 2004). Blanchard et al. (2010) emphasized that robotic coding activities require the use of problem-solving skills and creative thinking. Robotic-based tasks demand that students coordinate the physical movements of the robot with the virtual commands of their programming system, which is recognized as a detailed and intricate endeavour.

Programming

When reviewing the literature, it becomes evident that educational activities designed to enhance computational thinking skills often revolve around STEM (Science, Technology, Engineering, and

Mathematics) and programming activities. Since this study specifically investigates the impact of robotic coding activities on computational thinking skills, it focuses on programming-related activities while excluding STEM-based approaches. Programming has been recognized as particularly effective in developing various cognitive skills, including problem-solving, metacognitive thinking, creativity, analytical thinking, critical thinking, and algorithmic thinking (Akpınar & Altun, 2014; Atmatzidou & Demetriadis, 2016; Fesakis & Serafeim, 2009; Psycharis & Kallia, 2017). Therefore, it is reasonable to assume that programming activities can significantly contribute to the enhancement of computational thinking skills. The students' self-efficacy in programming skills has shown a significant increase, which aligns with the anticipated results of this study. This is because children must program the robots using a computer in order to interact with educational robots. This result is consistent with the existing body of research on the topic. Integrating robots into programming lessons helps make abstract concepts more tangible, both visually and physically, which facilitates students' understanding of computer science ideas (Noh & Lee, 2020). Programming is crucial for developing computational thinking (Lye & Koh, 2014) and stands out as one of the most effective methods for nurturing this skill (Pala & Mıhçı Türker, 2021). Existing research has demonstrated that programming education is directly linked to the development of computational thinking skills (Avello et al., 2020). For instance, Sun et al. (2022) found that students' attitudes towards programming were a significant predictor of their computational thinking abilities.

Computational Thinking

This study aimed to investigate the effects of robotic coding activities on students' self-efficacy perceptions of computational thinking. Expectations were aligned with prior research in the realm of computational thinking, which also demonstrated positive outcomes. The analysis revealed that the robotic coding activities had a statistically significant positive impact on students' self-efficacy perceptions of computational thinking. This finding aligns with similar studies in the literature, particularly those related to programming education. For instance, Karaahmetoglu and Korkmaz (2019) found that Arduino-based robotics had a significantly more positive effect on students' computational thinking skills compared to block-based programming. Similarly, Yilmaz Ince and Koc (2021) found significant improvements in algorithmic and critical thinking skills related to computational thinking, but no significant effect on creativity, cooperation, and problem-solving skills. In another study, Kert et al. (2020) revealed that robotic coding activities more effectively enhanced computational thinking skills compared to the group focused solely on programming. Also, Constantinou and Ioannou (2018) conducted two quasi-experimental studies—in their first study, they observed statistically significant improvements in computational thinking skills based on students' scores, while in their second study, significant improvements in computational thinking skills were noted among students in the experimental group, while the control group did not exhibit significant progress. Similarly, Noh and Lee (2020) employed a one-group pretest-posttest research design, akin to our present study, and the results demonstrated a statistically significant improvement in students' computational thinking skills due to robotic programming instruction.

Despite the similarity of common findings across studies employing diverse approaches and research designs, there are nuanced differences to consider. In a comprehensive literature review, Ioannou and Makridou (2018) examined research related to the influence of educational robots on the computational thinking skills of K–12 students. They stated that while the studies generally indicated the development of 21st-century skills, including computational thinking components such as decomposition, abstraction, algorithmic thinking, and debugging, it remains unclear to what extent these specific facets of computational thinking skills were enhanced in the context of robotic coding and computational thinking studies.

Gender

Witherspoon et al. (2017) identified a significant difference between pretest and posttest scores on computational thinking, however, the study found no notable gender-based differences. Remarkably, our study aligns closely with these findings, showing a similar significant improvement in computational thinking skills and a lack of gender-based differences. Likewise, Atmatzidou and Demetriadis (2016) reported no gender-based differences at the end of their implementation. However, they noted that females required more instructional time to achieve the same level of computational skills as males. Noh and Lee's (2020) study, like ours, demonstrated a statistically significant improvement in students' computational thinking skills as a result of robotic programming instruction. Importantly, the researchers observed no significant gender-based variations in the enhancement of computational thinking skills.

Upon comprehensive review of our study outcomes in conjunction with findings from related literature, it is clear that robotic coding activities have a positive impact on secondary school students' computational thinking skills. Consequently, these activities bear substantial significance for researchers looking to enhance this skill. The finding that gender does not significantly affect the outcomes is another noteworthy result of the study. Given these findings, the following recommendations are proposed, recognizing the limitations of the present study.

Conclusions and Recommendations

This study investigated the effects of robotic coding instruction, using the Lego Mindstorms Education EV3 set, on students' self-efficacy in computational thinking skills. Findings revealed a statistically significant improvement in students' perceptions of their abilities, with this positive change being consistent across genders.

The results of this study are limited by several factors, which future research could address by considering the following aspects. First, the study involved 32 students from the sixth and eighth grades. Future researchers in a similar context can enhance the diversity of their studies by including participants from various K–12 levels; focusing on participants from the same grade level may contribute to data reliability. Second, considering that this study employed a one-group pretest-posttest quasi-experimental design within a quantitative approach, researchers in similar contexts are encouraged to incorporate a control group when following a quantitative approach alone and to explore qualitative methods for deeper insights. Third, this study relied solely on the SEPSCTS. Diversifying data collection methods is another valuable recommendation. Future research can enrich data by incorporating various methods such as project or product evaluations, design assessments, portfolio evaluations, and algorithm assessments, as suggested by the literature for evaluating computational thinking skills (Brennan & Resnick, 2012; Chen et al., 2017; Koh et al., 2010). Fourth, the study was conducted with a limited number (5) of robotics kits. Conducting studies with individual students or pairs can eliminate some constraints and offer valuable comparability with activities that do not involve robotic programming. Fifth, extending instruction duration beyond the 20 hours provided in this study for more practice and project development is recommended. In longer-duration studies, participants could gain experience in instructor-guided project development for each task before independently developing authentic projects, recognizing the challenges in project development even after successfully completing individual tasks. Lastly, while ready-to-go robot kits are valuable, they are better suited for lower-grade levels in K–12 education. To nurture creativity and authenticity among higher-grade-level students, researchers might explore approaches involving physical programming with Arduino and similar platforms.

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Appendix

Sample Robotic Activities

Activity Name: 3m Competition

Purpose of the Activity: To ensure that students who examined the relationship between diameter and circumference in the previous activity work in a more motivated way, and to teach or reinforce the relationship between the road taken and the circumference of the wheel by doing and experiencing.

Duration of the Activity: 45 minutes

Materials to be Used: 5 Lego Mindstorms Education Set, 5 expansion sets, 5 computers, black electrical tape

Number of Participants: 20 (5 groups)

How the activity was conducted:

Competition: A competition is organized to make the participants work in a more fun way. Before the competition, the purpose of the competition is clearly explained to the students. It is emphasized that the competition is just for fun, and the result should not be evaluated in any other way.

A start line is set and a finish line is marked 3m away from the start line. Participants are asked to program their robots to stop at the closest distance to this line. It is stated that they must find the number of laps required for the program by calculating, and that they will not be allowed to make any attempts.

This competition is repeated for the other two wheels.

Activity Name: Ultrasonic Sensor

Purpose of the Activity: The aim of the activity is to introduce the concept of sensors, to enable students to establish a relationship between our sensory organs and sensors, and to program a robot that avoids obstacles using an ultrasonic sensor.

Duration of the Activity: 45 minutes

Materials to be Used: 5 Lego Mindstorms Education Set, 5 expansion sets, 5 computers

Number of Participants: 20 (5 groups)

How the activity was conducted:

Ultrasonic sensor: Students are introduced to the ultrasonic sensor and how it works. During the lecture, they are asked how bats detect objects. It is explained that the ultrasonic sensor of the robot works in a similar way.

How to use the ultrasonic sensor while programming is explained in the EV3 software interface. A simple to complex structure is followed. First, it is explained how to use the ultrasonic sensor with the wait for block. Then examples of transferring the data from the sensor to another block (wire) are given.

In addition, the loop block that students will use during the activity and how to use it will be explained.

Applications related to the ultrasonic sensor are made, such as a robot that turns back when it sees an obstacle or a robot that prints the distance of an object on the screen when approaching an object.

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StudyTracker Self-Tracking App and its Relationship to University Student Procrastination

L'application d'autosuivi *StudyTracker* et sa relation avec la procrastination des personnes étudiantes universitaires

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Abstract

Procrastination is a prevalent issue among university students and leads to long-term negative impacts on academic performance as well as mental health and quality of life. This paper investigated StudyTracker, a self-tracking digital application (app) that we developed for university students to use to track their study sessions. The app provided feedback to the student in the form of text and charts. We investigated the impact that StudyTracker had on procrastination habits, and explored how students interpreted their feedback data from the app. Results indicated that both the control group (N=9) and the experimental group (N=8) experienced a significant decrease in procrastination scores, however there was no significant difference between the two groups. The design implications of our findings are discussed.

Keywords: personal informatics, procrastination intervention, self-tracking, time management, university students

Résumé

La procrastination est un problème répandu chez les personnes étudiantes universitaires et entraîne des répercussions négatives à long terme sur les résultats académiques ainsi que sur la santé mentale et la qualité de vie. Cet article porte sur *StudyTracker*, une application numérique d'autosuivi que nous avons développée à l'intention des personnes étudiantes universitaires pour qu'elles puissent l'utiliser pour suivre leurs séances d'étude. L'application fournit une rétroaction à la personne étudiante sous forme de texte et de graphiques. Nous avons étudié l'impact de *StudyTracker* sur les habitudes de procrastination et exploré la manière dont les personnes étudiantes interprétaient les données de rétroaction fournies par l'application. Les résultats indiquent que le groupe de contrôle (N=9) et le groupe expérimental (N=8) ont connu une diminution significative des scores de procrastination, mais il n'y avait pas de différence significative entre les deux groupes. Les implications de nos résultats sur le plan de la conception sont discutées.

Mots-clés: informatique personnelle, intervention sur la procrastination, autosuivi, gestion du temps, personnes étudiantes universitaires

Introduction

Procrastination, the voluntarily postponing of an intended course of action on a task, is a widespread problem in higher education (Schraw et al., 2007). Studies vary as to the percentage of students who procrastinate. Steel (2007) estimated that between 70–95% of undergraduate students procrastinate to some degree. A study by Rahimi and Hall (2021) estimated that 46% of undergraduate and 60% of graduate students problematically procrastinate, where the procrastination resulted in negative outcomes. Several studies link academic procrastination to lower grades and lower academic performance (Balkis, 2013; Kim & Seo, 2015; Qaisar et al., 2017; Saplavaska & Jerunkova, 2018; Tice & Baumeister, 1997). Studies exploring the correlation between completion times and assignment grades showed that the earlier assignments were completed, the higher the grades (Cerezo et al., 2016; Yilmaz, 2017). In addition to academic performance, procrastination has significant negative consequences for emotional wellbeing, including shame, depression, stress, and anxiety (Rahimi & Hall, 2021). Our research began with the question of whether technology could be leveraged to help reduce academic procrastination in university students.

Persuasive design applies a variety of theories from areas of social psychology to alter attitudes and behaviours. Persuasive technology has been developed for this purpose (Fogg, 2003). Digital designs of these technologies include gamification (i.e., adding game-like elements such as points and badges), nudging (subtle cues that steer users towards a decision), triggers like notifications, and social proof (such as demonstrating how others have behaved, like leaderboards in games) (Fogg, 2003; Oinas-Kukkonen & Harjumaa, 2009). These features provide motivational affordances, which are designed to satisfy a user's intrinsic motivational needs (Zhang, 2008). Developing motivational affordances around positive behaviours may result in increased enjoyment and positive reinforcement. Technology has been shown to persuade individuals to reduce unwanted behaviours (Asmah et al. 2022). We were therefore initially inspired by the literature on persuasive design and its role in self-awareness and self-reflection.

Technology-based interventions for procrastination have recently become a growing area of academic interest (Lukas & Berking, 2018). There have been several Internet-based attempts to reduce procrastination, including email-based reminders (Zaveleta Bernuy et al., 2021), chatbots (Pereira & Díaz, 2021), and self-reporting apps (Bellhäuser et al., 2023). To study procrastination by medical students, Wäschle et al. (2014**)** used an online self-report that displayed a dynamic line chart that adaptively visualized each student's course progression and self-reported previous procrastination. The findings revealed that presenting visualized feedback to the students resulted in a significant decrease in future procrastination behaviour.

There are also many recent gamified apps that attempt to tackle procrastination as part of a wider life-goal-setting strategy, including TaskHero (Beta version) by Whetware (2024), WaterDo (Version 3.9.0) by Seekrtech (2024), Habitica (Version 3.12) by HabitRPG (2024), EpicWin (Version 1.0.17) by Supermono (2016), and Habit Hunter (Version 1.5.0) by Tien Long Nguyen (2024). The efficacy of these apps to impact academic results or procrastination is not known. In 2024, Kirchner-Krath et al. explored gamification's impact on procrastination. Lukas and Berking (2018) developed a mobile-based app called MT-PRO, which used gamification principles to reduce procrastination by asking users to either avoid dysfunctional stimuli (e.g., pictures showing typical alternative activities such as a student sitting in a study environment but engaging in social media activities; negative study-related statements) or to approach functional stimuli (e.g., pictures of a student sitting in a study environment engaging in academic tasks; positive study-related statements). Results showed that using the app reduced both general and academic procrastination behaviours.

Drawing on elements of goal-setting theory, self-determination theory, and operant conditioning, gamification often underpins many of the practical approaches to tackling procrastination, but these have not been the only approaches (e.g., Irwin & Edwards, 2019). When it comes to smartphone apps, there have been several approaches to reducing procrastination that include goal setting, reminders, time management tools (W. Zhao et al., 2023), timer-based strategies like Pomodoro technique (S. Zhao et al., 2023), cognitive behavioural therapy (Lukas & Berking, 2018), and therapist-guided self-help interventions (Rozental et al., 2015). These interventions have an impact during the study periods, however long-term impacts are unknown.

Theobald and Bellhäuser (2022) had students complete daily electronic survey-based learning diaries. Their findings showed that automated electronic feedback (either informative, directive, or transformative informative) positively impacted student procrastination habits, self-regulated learning, and goal-achievement, and students in the feedback group received better grades on the final exam. However, motivation and self-efficacy were unaffected by the feedback. A subsequent study by Bellhäuser et al. (2023) created a goal-setting app to enhance self-regulated learning that provided daily automated, adaptive feedback, based on responses to daily electronic learning diaries. They found that their intervention increased goal setting and self-efficacy, but motivation, procrastination, and effort were unaffected. It is unclear why students in the first study (Theobald & Bellhäuser**,** 2022) experienced a decrease in procrastination, whereas students in the second study (Bellhäuser et al., 2023) did not, as both studies used learning diaries paired with similar combinations and types of feedback.

Apps with regular reminder notices focused specifically on online-only learning platforms increased adherence to deadlines (Bartuskova & Krejcar, 2014; Romero et al., 2016). Other apps focused on reducing distracting behaviours via playing games, using the Internet or smartphones (Foulonneau et al., 2016; Jacobsen & Pedersen, 2021; Kovacs et al., 2019; Schwabe, 2020). These apps were shown to have limited effects when the problem was not a specific distraction, but a general desire to be distracted by anything other than the task at hand (ibid.).

Proccoli is an app that combined Pomodoro-style timers, progress reporting, charting, notifications, self-evaluation, and goal setting (S. Zhao et al., 2023). While the study found that the app had positive results on procrastination for some participants, it is not known which of the app's design features had a significant effect, although competition between classmates may have been a key factor. Missing in the existing research is a dedicated focus on a single design feature to understand digital procrastination interventions, e.g., the role of behavioural tracking or self-tracking as a motivational affordance in procrastination apps.

Self-tracking, in which individuals monitor, measure, and record data about their body and life, has been practiced for a long time with the use of pen and paper (Ayobi et al., 2018). Recent advances in wearable technology have resulted in a resurgent interest in self-tracking, since devices like the Fitbit and mobile heart rate monitors easily facilitate the process of collecting and analyzing data. Although self-tracking is often referred to as quantified self, non-quantifiable data such as daily activities, moods, and relationships, can also be tracked. By tracking habits over time, insights into time management, increased self-observation, and improvements in self-reflection can be gained.

Fogg (2003) refers to self-tracking as one of the foundational persuasive technology techniques, where the technology can remove the tedium of tracking performance. Gimpel et al. (2019) found that entertainment was a large motivator for self-tracking. They reported that self-tracking users enjoyed playing with their collected data, considering it entertaining. As a result, these users were more likely to be dedicated to their self-tracking practice. They observed that users who adhered to their self-tracking practice often realized that it was helping them take responsibility, optimize their lives, and be more self-disciplined, regardless of their motivation for tracking.

Self-tracking technologies are beneficial for the user (Stiglbauer et al., 2019). Several studies involve self-tracking technologies and academic productivity. For example, Wohn and Lee (2020) explored how tracking and reflecting on study habits impacted study behaviour and grades. Participants were in one of five conditions: (1) control group (no tracking or reflection), (2) tracking only, (3) tracking and self-reflection, (4) tracking and social reflection, and (5) tracking, self-reflection, and social reflection. Participants in the self-reflection conditions wrote a journal entry once every two weeks reflecting on their tracking data, performance in class, and general study habits. Participants in the social reflection conditions shared those reflections with a small group during class. The participants who combined tracking with active self-reflection received significantly higher grades on their final exams than participants who combined tracking with social reflection, although there were no other statistically significant differences between groups thus making it unclear how much of a positive impact self-reflection alone had on student study behaviours. Notably, Wohn and Lee did not assess the impact that tracking and self-reflection had on procrastination. A study by Tabuenca et al. (2015) explored the impact that self-monitoring and notifications had on self-regulated learning and showed that self-monitoring study time may have a positive impact on time management skills.

The practice of self-tracking using digital technologies is also referred to as quantified self (Abend & Fuchs, 2016) and personal informatics (Zuckerman & Gal-Oz, 2014). Studies have shown that these technologies can be used to effectively change people's behaviour when it comes to physical activity (Zuckerman & Gal-Oz, 2014) and mood (Bakker & Rickard, 2018). Visualization is the main method of communicating this information to the user and helps in self-reflection. Data visualization improves academic performance (Aguilar, 2018) and motivation (Huang, 2022; Velázquez-Iturbide et al., 2017). To increase usability, Oh and Lee (2015) recommend making user input simple and automated, thereby reducing time or mental effort to record data. However, Choe et al. (2014) suggest that self-tracking tools should maximize the benefits of manual self-tracking, because automated tracking may reduce awareness and self-reflection. Manual tracking requires users to actively input their data, creating a moment for them to engage in analysis and reflection. The act of recording data manually not only increases awareness but may also encourage individuals to consider what the data reveals about their performance, allowing them to identify opportunities for behaviour change. Therefore, it is important to find a balance between automated and manual data collection to increase usability, while still preserving user awareness of the data.

This paper investigated whether self-tracking, in the absence of intentional gamified or social elements, could be an effective tool for reducing procrastination in university students. StudyTracker, an app that students could use to track their study sessions and visualize their data, was developed. An initial exploratory study was conducted to understand students' general thoughts on the app, followed by a six-week randomized controlled trial to examine whether the app had a positive impact on procrastination habits. The overall research question was whether participants in the experimental group would report a greater decrease in procrastination compared to participants in the control group.

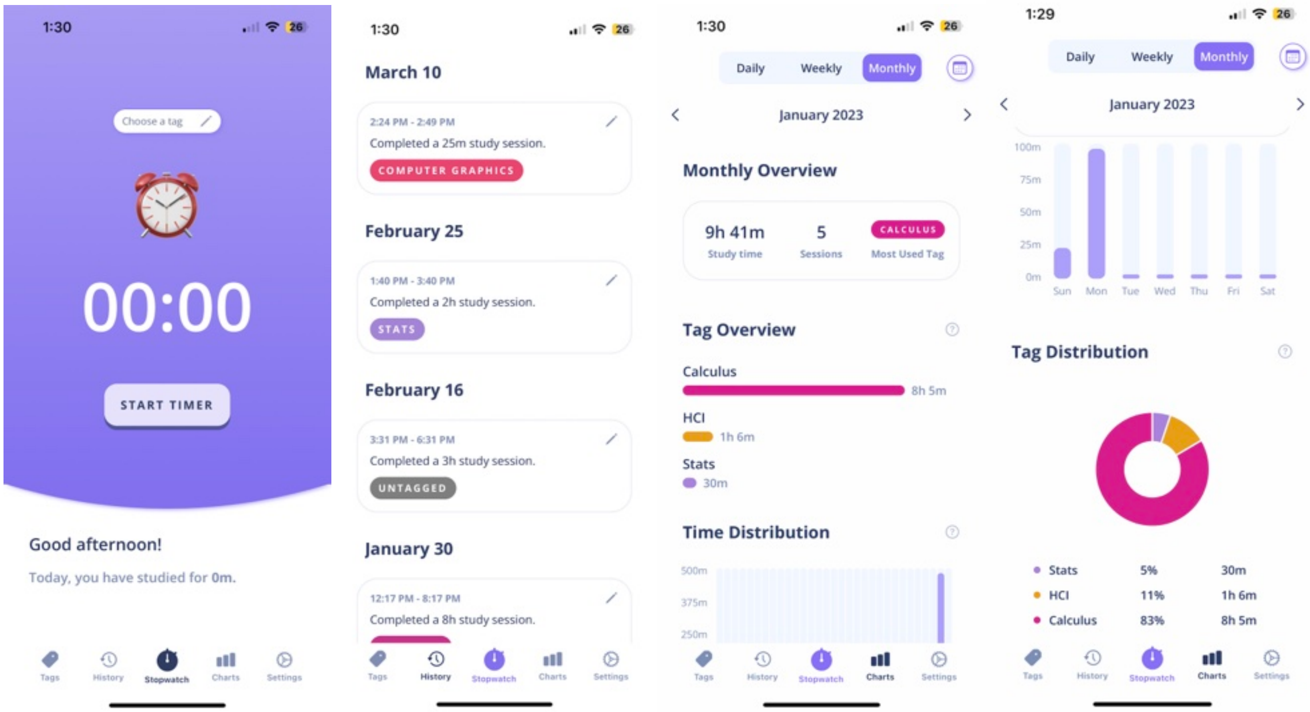
The StudyTracker App

We designed our StudyTracker mobile app to focus on self-tracking and visualized feedback, without intentional gamification or social elements. It is important to note that our StudyTracker app is distinct from Korata Software (2024) Study Tracker (Version 2.4.8), or any other available app with a similar name. Our StudyTracker app was specifically implemented for this study and is not publicly available.

StudyTracker used semi-automated self-tracking, in which the user was required to manually start and stop the timer before and after study sessions. Timings would then be stored and visualized automatically by the app in the form of charts and text feedback. The app featured a timer, charts, tags, a log of sessions, and settings. Like other productivity apps, the timer was on the home page making it easily accessible to the user (Figure 1). There was a start-timer button that the user could press to start timing their session. Upon clicking the button, it toggled to the stop-timer button. The timer ran in the background even if the user closed the app. Tags were added to allow the user to organize their sessions by topic. The data from the tags were used to provide additional feedback to the user. The user could select a tag when they started a new session or edit the tag of a session afterwards, including the options to change the label, colour, and add or remove tags from a session. A history section provided a log of previous sessions. Users could select recorded sessions and edit the start time, end time, and tag associated with that session. A charts section included visual feedback for the users. Charts were inspired by popular apps, such as Seekrtech (2024) Forest (Version 4.79.0) and Pixo (2024) Focus Keeper (Version 2.8.4). The charts included a daily, weekly, and monthly view.

Figure 1

The Implemented StudyTracker App, Version 1.0



We first conducted a usability study on a high-fidelity prototype of the app (Version 1.0), with eight participants to ensure that the application design was usable. We used the System Usability Scale (SUS), a common measure of usability assessment consisting of a 10-item questionnaire. Lewis (2018) provides a thorough historic overview of the SUS. The mean average SUS score was 83.75 (out of a possible 100; Lewis and Sauro (2018) rate this in the top 90^{th} to 95^{th} percentile of scores), indicating that the application design was usable and effective.

Following the usability study, one researcher implemented a working version of StudyTracker (Version 1.0), made available for download on iOS devices through an invite link. This article presents findings from two studies: a pilot study conducted to evaluate the app's functionality, and a randomized trial aimed at exploring the relationship between app usage and changes in procrastination behaviour among university students. In both studies, participants received instruction on how to download StudyTracker onto their devices and about the features available. Students were then asked to use the app during academic-related tasks (e.g., studying, completing assignments) by timing their sessions. Regular app usage however was difficult to enforce, and determining whether participants were actively reflecting on their data was a challenge. Therefore, a more qualitative approach to data collection and analysis was taken, focusing on participant experiences with our StudyTracker app.

A Pilot Study into StudyTracker's Functionality

The pilot study was completed to ensure that StudyTracker was working as expected and to gather students' initial thoughts about the app. For this study, student feedback on the StudyTracker 1.0 app was sought. Through social media, seven participant students at the university were recruited, five of whom self-identified as women, one as a man, and one as other. Ages ranged from 18 to 51 years (M=27.43, SD=11.21). Four were undergraduate students and four were master's students. Five participants had experience using self-tracking technologies such as fitness trackers, however, none of the participants had prior experience using self-tracking apps for studying.

Participants used StudyTracker during academic-related tasks for 10 days, after which semi-structured interviews were conducted and included questions about the app's functionality, features, user interface, and the participants' overall experience using the app. Participants were also asked if they felt their procrastination habits had improved from using the app. Study participants were compensated with a $25 Amazon e-gift card for their participation.

A thematic analysis on the interview transcripts was performed. Overall, participants noticed positive changes in their study habits and procrastination. Four themes emerged from the interviews:

Increased Focus and Productivity: Four participants mentioned that the app helped them focus when they would have otherwise gotten distracted. Specifically, P5 said that their focus had increased because it felt like they were being managed.

Time Management: Five participants said that the charts helped them better plan and manage their time in some way. From analyzing the data in the charts, they were able to see which topics they spent the most time on and what times of day they were most productive. With this information, these participants were able to optimize their study sessions. P1 said that the charts and tag feature helped them think more critically about how they were spending their time.

Accountability: The app helped participants feel more accountable for their schoolwork. Three participants described that keeping a "record" of their study sessions enforced the fact that they should study. If the timer was running, these participants wanted to be studying. P1 described that having the timer running made it feel like somebody was watching. P3 stated that starting the timer acted as a "pledge" to begin studying.

Entertainment: The app made two participants feel like they were playing a game: Seeing their feedback made them want to compete against themselves and get higher "scores." P2 explained, "this is actually a good app because it makes me productive because I want to beat the timer. I want a large number on the timer." Interestingly, even in the absence of intentional gamified design features, two students still gamified the app on their own, perhaps indicating a desire for more gamified elements.

Participants had several suggestions to improve the app. A common problem was forgetting to start or stop the timer. Four participants suggested that a notification would help solve this problem, however students further indicated that daily reminder notifications were not preferred. Three participants said that they felt that more variety in the charts section was needed.

The results of this pilot study showed that there was potential for self-tracking technologies to act as an intervention for procrastination. All participants expressed that they enjoyed the app in some way and felt it had a positive impact on their academic procrastination habits. All participants reported experiencing improvements in at least one area—time management skills, focus, productivity, or accountability—supporting the possibility that the app may have a long-term positive impact on procrastination.

Several feature suggestions were taken from this pilot study and implemented within the app. First, a notification feature was added to remind users when the timer is running so they do not forget to turn it off. Also, the timer was set to automatically stop and record the session after eight hours. Daily notification reminders were not added because notifications have already been shown to impact student procrastination behaviours (Davis & Abbitt, 2013). Instead, one self-tracking feature was isolated to examine its impact on procrastination.

Randomized Trial to Test the App's Relationship to Procrastination

After the pilot study, and as suggested by the participants, the following features in the app, now called StudyTracker 2.0, were implemented: (1) a notification to remind users that the app is running, and (2) a button to display more information about each chart. A six-week randomized trial to explore the relationship between StudyTracker 2.0 and the procrastination habits of university students was conducted. It was anticipated that students in the experimental group would experience a greater decrease in procrastination than students in the control group. Also, there was an exploratory component to this study, which investigated how students interacted with and interpreted their data, as well as the overall impact that the app had on students' study behaviours. The following research questions guided our investigation:

(1) How does the use of the StudyTracker 2.0 app influence procrastination behaviour among university students?

(2) What insights do students gain from their study data and how do they use these insights to improve their study habits?

(3) What is the overall impact of the app on students' study behaviours?

Methods

Participants

Using the same eligibility requirements as in the pilot study, 18 participants were recruited through social media. Participants completed the consent form followed by a pre-study survey containing questions about their demographics and experience with self-tracking technologies. Participants were also asked what tools they had tried, or were currently using, to reduce procrastination. None of the participants had experience using study trackers.

Participants were assigned to either the control group or the experimental group using block randomization. The control group (N=9) included five self-identified women and four self-identified men. Ages ranged from 18 to 26 years. The experimental group (N=8) included seven self-identified women, one self-identified man, and one self-identified as other. Ages ranged from 18 to 24 years. Seventeen participants completed all phases of the study, because one participant withdrew after completing three of the weekly surveys. Their survey responses were used in the qualitative analysis, but their data were not used in the statistical analysis.

Procedure

Two instruments were used to measure participant procrastination habits. For overall procrastination levels pre-study and post-study measurements, the Academic Procrastination Scale (APS) was used (McCloskey & Scielzo, 2015) because it focuses on academic procrastination rather than general procrastination and is relatively short compared to other scales. The APS contains 25 items that are rated on a Likert-type scale from 1 (Disagree) to 5 (Agree). Both groups received the long form of the APS before and after the study. To monitor weekly procrastination habit changes, students responded to a weekly survey containing the Academic Procrastination Scale – Short Form (APS-SF) (Yockey, 2016). The APS-SF contains 5 items from the APS which are rated on a Likert scale from 1 (Disagree) to 5 (Agree) and was chosen to ensure that students had enough time to complete it in addition to their schoolwork. Weekly surveys included the short form which participants completed each week for the six weeks.

The experimental group received additional information including instructions on how to download the app onto their device through an anonymous link, thereby ensuring that information about their app usage was not received by us. Participants were instructed to use the app during academic-related tasks for six weeks. Every seven days, in addition to receiving the APS-SF, they were sent a survey about their experience using the app. At the end of the study, the experimental group was sent questions about the self-tracking app and feedback, in addition to the post-study APS.

Results

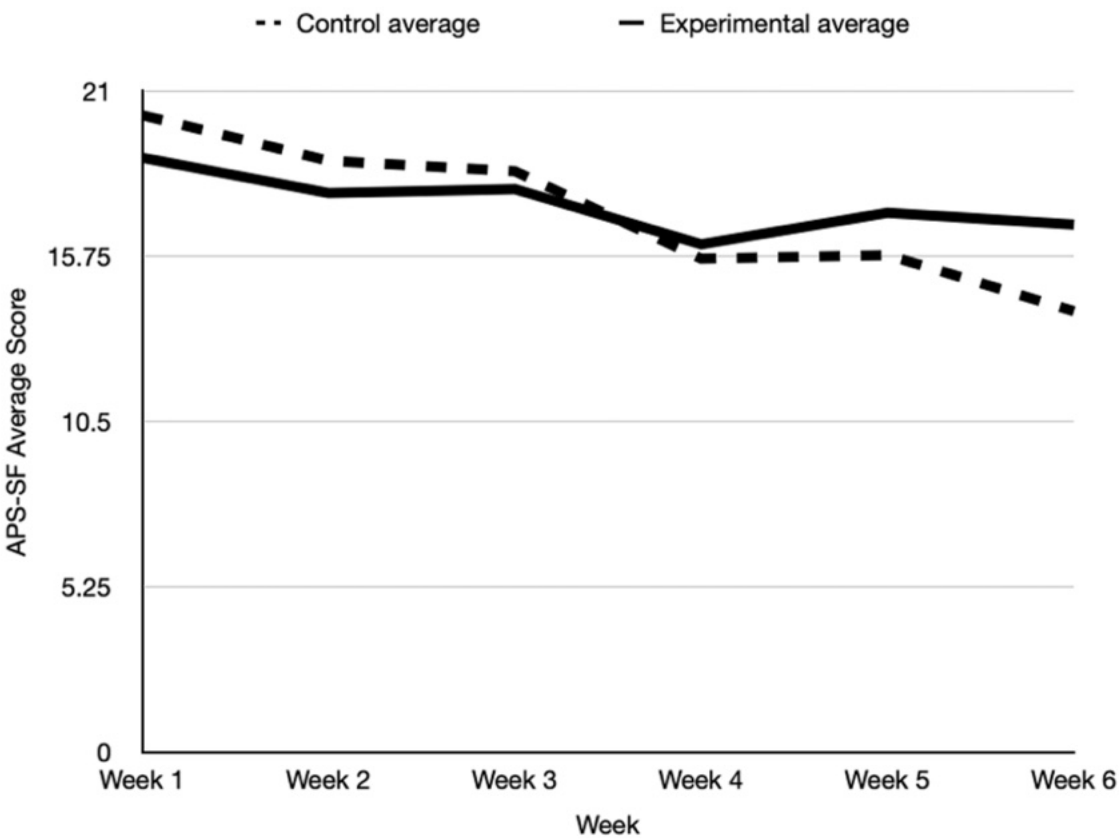
A paired samples t-test was conducted to determine the change in APS scores within the groups. Results showed that the control group experienced a significant decrease from their baseline scores ($M=64.56$, $SD=8.31$) to final scores ($M=41.89$, $SD=20.2$, $t(8)=3.11$, $p=.007$). The experimental group experienced a significant decrease from their baseline scores ($M=56.38$, $SD=9.52$) to final scores ($M=42.63$, $SD=18.63$, $t(7)=1.98$, $p=.044$).

A repeated-measures ANOVA determined that the mean APS-SF scores within the control group differed significantly across the weeks ($F(5,40)=5.79$, $p=<.001$). A post hoc analysis showed that scores became significantly different during week four of six ($M=15.67$, $SD=4.27$), although the cause cannot be determined, except to suggest that changes in workload during the term likely influenced their ability to stay on track.

A repeated-measures ANOVA determined that the mean APS-SF scores within the experimental group did not differ significantly across weeks one through six ($F(5,35)=1.194$, $p=.332$). Average weekly scores are summarized in Figure 2.

Figure 2

Average Weekly Scores on the APS-SF



An independent samples t-test was conducted to determine the significance of the difference in baseline and final APS scores between the two groups. The results indicated that there was no significant difference between the groups ($t(15)=.88$, $p=.393$), although the control group ($M=22.67$, $SD=21.89$) experienced a greater decrease in scores than the experimental group ($M=13.75$, $SD=19.67$).

Frequency of Use and Procrastination Scores

The weekly survey asked experimental group participants how often they tracked their study sessions (0% of the time, 25% of the time, 50% of the time, 75% of the time, or 100% of the time). While there was a small positive correlation between the two variables, the relationship was not statistically significant.

Survey Responses and Reflections

Thematic analysis was used to examine all qualitative survey responses. Feedback from the app made three participants realize that they studied for less time than they thought, which resulted in various reactions; *seeing how much time I spent on tasks versus how much time I should be spending has been eye-opening.* (P15). For two of these participants, this information encouraged them to study more. For example, P7 wanted to stop studying, however, the timer helped them to realize that they had been studying for a short amount of time, which motivated them to continue studying. However, for P3, the realization that they study less than they thought was not enough to push them to study more. Gaining a sense of time spent also helped participants become more aware of the progress they were making. For example, P20 said, *[the app] helped visualize how much work I was doing even though it may have felt like I was not making progress*. Measuring progress helped participants recognize what they were accomplishing, giving them a sense of achievement and motivation to keep working, reinforcing positive behaviours.

Feedback from the app was considered informative with some experiencing a positive change to procrastination behaviours. Overall, the app helped participants increase their reported focus. For example, the app served as a reminder for P4 to not get distracted whenever they picked up their phone. In addition to the timer acting as a reminder for P4 to study, they also knew that the app was tracking them, and they did not want there to be any “false” data, which discouraged them from getting distracted. P20 felt similar effects, explaining that getting distracted meant they had to either deduct time from their data or stop the timer, which they wanted to avoid. Keeping their data accurate also allowed them to reflect on this data, helping them make changes to their study habits:

> *The more I spent tracking my productive tasks, the more it forced me to focus on the task. As if I started something else or got distracted, I had to stop the timer or subconsciously deduct time counted. This made me more focused, and on track instead of getting distracted with other things*. (P20)

Additionally, three participants said that using the app helped them study for longer periods of time, as explained by P7, *Maybe [the app did] not completely reduce procrastination, but more so improve my study retention time. I am able to study for longer and more concentrated periods of time.* For some participants, the app helped them get into a “study mindset,” allowing them to focus on their work. P15 referred to tracking as their *study ritual*. P7 said that the app acted as a *signal* to their brain that they were going to start studying. An interesting and unexpected result was that the app could be considered a tool to prime a user to study. By encouraging greater self-awareness and self-reflection on study habits, the app became part of a study ritual, creating environmental and cognitive cues that help participants transition into a study mindset. The app could be a priming stimulus that signals to students the purpose of their session and reinforces study behaviour.

Five participants mentioned that the feedback helped them identify on which topics they were spending time. This information allowed them to purposefully allocate their time across their various courses. Furthermore, the feedback encouraged P4 to get started on topics that they would have otherwise pushed aside:

> *The daily overview helped me see how long I studied in the day and how many exact sessions I needed and what courses along with the tag overview so it would be in an easier way to see which courses got the most focus in that day and it would encourage me to study for another course tomorrow (one that got less attention from the previous study session).*

Six participants said that the tag feature was their favourite. Three participants expressed support indicating that tags were useful when it came to allocating their time because they were able to compare the time they spent on each topic. Four participants used the feedback to understand when they were most productive, and then manage their time accordingly. P5 said that seeing when they are most productive helped them with future planning; *I like that it allows me to see when I am most productive or when I tend to do work. I could apply that when devising future plans*.

Additionally, four participants used the feedback from the charts to learn how much time it took them to complete tasks such as assignments, so they could plan their study sessions accordingly. For example, P15 expressed, *it also helped me see how much time I was spending on tasks, and I could more effectively plan and get my tasks done because I knew how much time the task required*.

Seven participants reported at least one instance of forgetting to start the timer when they began studying, whereas only one participant was easily able to integrate the app into their study routine. Another participant made a habit of using the app at the beginning of the study but began to forget to start the timer as they lost interest in the app. P1 and P7 recommended strategically timed notification reminders be added based on the users' peak study time data, to help remind them to track their study sessions. For instance, if a student successfully completed most of their focused study time between 7–8pm, then the app could send a reminder before 7pm suggesting study time be started. Similarly, P14 and P5 recommended general reminder notifications that the app exists.

Three participants valued the accuracy of their data and reported using the app as often as they could to keep their data accurate. Two participants expressed frustration because they would forget to start the timer while studying but remember once they had finished. As a work around, P5 stated they would run the timer afterwards to *make up* for the time they forgot to track. These participants suggested manual data entry as an effective solution to the problem of forgetting to start or stop the timer.

Three participants expressed boredom with the app, suggesting the interface was not engaging enough. P14 said that the app had *minimal functions*, while P3 said that it was *pretty bare bones*. The lack of features led P14 to stop using the app altogether stating, *towards week four I lost interest in the app, because there are very minimal features that I could use*. P7 suggested they would have liked to have more gamified and social features.

Within both groups, results showed a significant decrease in procrastination scores. However, between the two groups, there was no significant difference in scores. This result does not support our expectation that the experimental group would experience a greater decrease in self-reported procrastination scores than the control group. Furthermore, although the difference was found to be statistically insignificant, the control group experienced a larger decrease in APS scores than the experimental group. There could be several reasons for this result.

First, three participants in the experimental group found that the app was not engaging enough, and it was hard to remember to start the timer whenever they began studying. Higher engagement with the app may have resulted in an overall higher decrease in procrastination scores within the experimental group. The app cannot help the participants if they do not use its features to their full potential, however there was no dependable way to ensure that participants were engaging with the app while doing schoolwork. Second, the natural progression of the semester may have had an impact on all procrastination scores. Since this study was performed over the course of a semester, two participants expressed that they noticed a positive change in their procrastination habits because they could no longer "afford" to procrastinate as midterms and exams approached. Regardless, it can be concluded that the self-tracking app was simply not enough to impact procrastination significantly, resulting in similar experiences between the control and experimental groups. Although the control group's procrastination habits may have been impacted by the weekly procrastination survey, the experimental group also responded to this same weekly survey. Overall, the effects of using the app would have been evident if the app was truly effective. Third, the fact that the control group was asked to respond to weekly feedback may have been enough to influence their results, since they may have felt accountable to the study.

Results aligned with the Wohn and Lee (2020) study conclusions that self-tracking is not enough to have a significant impact on student study habits and grades, although they did not examine procrastination specifically. Our results are contrary to Wäschle et al. (2014) that concluded that students who received weekly visual feedback experienced a stronger reduction in procrastination compared to students in a controlled condition. In addition to procrastination, how the app impacted study behaviour was also explored; finding that the app had a positive impact on time management skills, although this variable was not assessed quantitatively. This finding aligned with Tabuenca et al. (2015) where they also found that self-tracking study time may have a positive impact on time management skills.

Overall, the random trial of StudyTracker 2.0 shows that use of a self-tracking app was not enough of an intervention, to reduce academic procrastination in university students. However, the app helped seven participants gain new skills such as time management, which was a benefit that the control group did not experience. Regardless, this was not enough to significantly decrease procrastination scores when compared to the control group as measured by the APS and APS-SF. We suggest that students must have a strong willingness to change their procrastination habits for an intervention such as a self-tracking study app to make a positive impact. Otherwise, students will not commit to habitually timing their study sessions, nor will they invest time into reflecting on their study data. Future studies could consider pre-selecting participants who indicate a strong willingness to change their procrastination habits. Removing the willingness or motivation factor from the equation would therefore allow a future study to test the "effectiveness" of an intervention to change the behaviour.

Discussion and Design Implications

Through the app design and qualitative results from the pilot and randomized trial studies, insights on how students interpret their data and several design recommendations for productivity-focused semi-automated tracking apps were applied. Persuasive design practitioners may find the following recommendations and insights useful.

Recommendations and Insights

Reminder Notifications

Notification reminders are essential, however should be controllable by the user. Since the self-tracking feature was semi-automated, requiring some active user intervention, participants often forgot to start the timer when they began studying. This was particularly evident in the randomized trial, where seven out of eight participants in the experimental group reported forgetting to use the app at least once. This high rate of forgetfulness among university students may reflect their busy schedules or the cognitive load of managing multiple responsibilities. Interestingly, the control group also experienced a decrease in procrastination scores, possibly due to the reflective nature of responding to the weekly surveys. This suggests that a simpler solution, such as weekly surveys, might be more suitable for university students as they require less effort and impose a lower cognitive load compared to consistent app usage.

Despite the forgetfulness, three participants from the pilot study said that they considered reminders annoying. Only two participants from the randomized trial who reported at least one incident of forgetting to start the timer while doing schoolwork recommended designing general reminders into a future version of the app. However, another solution recommended by two participants was strategically-timed personal notifications sent after the app learned the user's peak study times. This may be difficult to implement, and therefore we recommend customizable notifications, where users control when and how often they receive notification reminders.

Ensuring that Data is Accurate

When self-tracking is semi-automated, requiring some active user intervention to start and stop the timer, it is essential to provide tools that allow users to edit and add data. Semi-automated tracking introduces the potential for human error. Six participants (three from the pilot study and three from the randomized trial) valued the accuracy of their data, supporting the suggestion to include options for data editing and manual entry in the self-tracking apps. Specifically, users should be able to edit the start and end times of existing entries and have the option to manually create new entries without running a timer.

Optimizing Data Visualizations

When analyzing charts, participants gathered specific insights to help them better manage their time. Three themes that classify the ways in which participants interpreted their data were discovered: (1) topic balance, (2) peak productivity times, and (3) task duration. Five participants from the randomized trial often used the charts to determine which topics and tasks were taking most of their time, which allowed them to better allocate their time across different topics and tasks. Four participants used this information to plan study sessions because they had a better estimate of how much time was needed for each task and topic. Three participants from the pilot study stated that they would like a wider variety of chart options, specifically they would have liked the same information but displayed differently. In the randomized trial, there was a lack of pattern in the charts that participants preferred. This suggests that a variety of charts should be provided, since there is no universal preference. Ideally, we recommend that self-tracking apps include a customizable dashboard in which users can display their preferred charts. Future research could explore which data visualizations are most effective for driving behavioural change, considering factors such as user demographics and the target behaviour.

Tags

Participants found the tagging feature was helpful to determine topic balance and task duration.

Productive Time Tracking

Based on the time of day that participants logged the longest study sessions, participants were able to determine the times of day that worked best for them and plan to study during those hours. To help identify peak study times, charts that display time of day and average logged study times could be used and accompanied by textual feedback informing about peak productivity times, so users can easily interpret the data.

Limitations

Some limitations may have impacted the results of this study. One limitation was the smaller number of participants, and therefore, the results are not generalizable. Furthermore, the study only looked at one variable: procrastination. Future studies would benefit from looking into how self-tracking apps quantitatively impact additional variables such as general productivity, motivation, time management, achievement, and focus.

Another limitation was that results were self-reported rather than potentially measuring their academic achievement over time. It is difficult to know exactly how procrastination was impacted, since self-reported measures may be biased. Engagement data were also self-reported. Although participants were asked how often they tracked their study sessions, data were not collected on how often participants interacted with and reflected upon the app feedback. Future studies may benefit from investigating the impact of user engagement on effectiveness of self-tracking apps in promoting behaviour change more in-depth. Moreover, app analytics that learn user habits and make suggestions over time may also lead to greater improvements in study behaviours and behavioural changes in a wider context.

Despite the quantitative results being inconclusive, the qualitative results from the randomized trial showed that six students gained motivation and awareness, which as described are critical to self-regulated learning. Future studies are warranted to investigate motivational affordances and to consider gamified and social elements.

Somewhat counter to the quantitative results, the qualitative results of the study suggest that self-reflection may be an important counter to procrastination habits, whether that self-reflection happens in the form of weekly surveys or through a data-tracking app, or both. Providing tools along with the data to facilitate such self-reflection on their habits could be the most important design features that could be incorporated into apps: Simple data tracking is not enough to sustain student engagement and motivation. More advanced features such as analytics, gamified elements, and artificially intelligent systems that can learn and provide recommendations as well as perhaps teach users how to read and interpret their data, may be necessary for continued engagement.

Conclusions

This study is an exploration of the StudyTracker app, a self-tracking tool designed to help university students reduce procrastination by providing visualized feedback on their study habits. The app intentionally avoided gamification and social elements, focusing instead on self-awareness and reflection.

Procrastination remains a significant challenge among university students, often leading to negative consequences for academic performance and mental wellbeing. This study showed that while both experimental and control groups experienced a significant decrease in procrastination scores, the StudyTracker app did not lead to a greater reduction in procrastination compared to the control group. However, qualitative insights revealed that the app fostered improvements in time management, focus, and self-reflection among some users, which are critical components of self-regulated learning.

These findings underscore the importance of further research into self-tracking technologies as potential tools for tackling procrastination, while emphasizing the need for features that actively engage users and sustain motivation.

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Technological Tool for Formative Assessment in Higher Education: ZipGrade

Outil technologique pour l'évaluation formative dans l'enseignement supérieur : ZipGrade

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Abstract

This descriptive study examines the effectiveness of ZipGrade, a digital assessment tool, in the context of formative evaluations within classroom settings, focusing on its deployment for multiple-choice question quizzes. This research contributes to the dialogue on the integration of information and communication technology to promote quality education and address the literature gap in providing immediate feedback to enhance the learning outcomes. Drawing on a sample of 63 fourth year B.Ed. students in Bahrain, the study combines quantitative and qualitative methodologies to assess student perceptions about the utility and effectiveness of ZipGrade. Data were collected through a semi-structured questionnaire following the administration of a series of formative tests across selected course segments. The findings reveal a predominantly positive reception of ZipGrade among students, highlighting its ease of use, immediate feedback provision, and potential to more effectively engage learners in the assessment process. Challenges such as the necessity to physically print answer sheets, a predisposition towards multiple-choice questions, and infrastructural and policy-related barriers were identified, suggesting areas for further development and support.

Keywords: digital assessment, education quality, student feedback, teaching effectiveness, ZipGrade

Résumé

Cette étude descriptive examine l'efficacité de *ZipGrade*, un outil d'évaluation numérique, dans le contexte des évaluations formatives en classe, en se concentrant sur son déploiement pour les questionnaires à choix multiples. Cette recherche contribue au dialogue sur l'intégration des technologies de l'information et de la communication pour promouvoir une éducation de qualité et combler les lacunes de la littérature concernant la transmission d'une rétroaction immédiate afin d'améliorer les résultats de l'apprentissage. Utilisant un échantillon de 63 personnes étudiantes de quatrième année du B.Éd. à Bahreïn, l'étude combine des méthodologies quantitatives et qualitatives pour évaluer les perceptions des personnes étudiantes sur l'utilité et l'efficacité de *ZipGrade*. Les données ont été collectées à l'aide d'un questionnaire semi-structuré après l'administration d'une série de tests formatifs sur des segments du cours sélectionnés. Les résultats révèlent un accueil majoritairement positif de *ZipGrade* parmi les personnes étudiantes, soulignant sa facilité d'utilisation, sa capacité à fournir une rétroaction immédiate et son potentiel à impliquer les personnes étudiantes de manière plus efficace dans le processus d'évaluation. Des défis tels que la nécessité d'imprimer physiquement les feuilles de réponses, une prédisposition envers les questionnaires à choix multiple, et des barrières liées à l'infrastructure et à la politique ont été identifiés, suggérant des éléments pouvant être développés et soutenus davantage dans le futur.

Mots-clés : évaluation numérique, qualité de l'éducation, rétroaction des personnes étudiantes, efficacité de l'enseignement, ZipGrade

Introduction

Using digital technology for teaching and learning has become necessary, especially after the COVID-19 pandemic and subsequent lockdowns. Through several studies (Henderson et al., 2015; Muslu, 2017; Perrotta, 2013; Prensky, 2001), the efficacy of digital tools and applications has been established in terms of knowledge retention, independent learning, collaboration, and for learning life skills. Technology use makes teaching and learning more convenient, efficient, engaging, and enjoyable.

Assessment is as crucial as teaching and learning. It ensures that students and teachers have understood various aspects of a concept and helps identify gaps in learning when the teaching matter has not been fully absorbed (Bhuvaneswari & Elatharasan, 2019). Using technology in assessment has created new possibilities and approaches. Depending on the purpose of assessment, including diagnostic, formative, or summative, different assessment tools have been designed and implemented for subjects like math, science, history, and languages (Bhuvaneswari & Elatharasan, 2019; Şimşek et al., 2017). For larger classrooms and more timely feedback, mobile camera-based educational tools have been tested (Blattler et al., 2023; Wagstaff et al., 2019) and a few digital applications evaluated (Cherner et al., 2016; Muslu, 2017; Şimşek et al., 2017). Further, Lookadoo et al. (2017) also experimented with instructional video games.

Research on the use of digital technology for assessment has focused on students in K-12 and higher education community colleges. It is imperative to consider the attitude and perception of teachers and students toward different types of assessments, including digital assessments (Goodenough, 2019; Guo & Yan, 2019; Hendrith, 2017; Ningsih & Mulyono, 2019; Wagstaff et al., 2019). Over the last decade, digital software tools examined within their theoretical and practical frameworks included: Kahoot, Quizlet live, Socrative, Nearpod, ZipGrade, Snaptron (an education tool for exam grading using machine learning and OMR), instructional video games, Plickers (an educational tool for assessment by scanning student cards), Electronic Based Assessment, GeoGebra, the QR Code Reader, Schoology, and The Physics Classroom.

Many teachers, particularly those from older generations, resist using digital technology primarily due to its challenging implementation in a traditional classroom (Atkins & Vasu, 2000). Prensky (2001) introduced the term, *Digital Immigrants,* for people who were not born into the digital world and adopted aspects of new technologies at a later point in their lives. Prensky further calls younger generations, *Digital Natives*, describing them as young people who are native, digital language speakers of computers or Internet who began by processing information differently. These digital natives want instant gratification for their work, which for educators requires multitasking and parallel thinking. Prensky (2009) suggests that we should focus on the development of what he calls *digital wisdom* and emphasizes, "Digital technology, I believe, can be used to make us not just smarter but truly wiser" (para. 2).

E-learning initiatives in the Kingdom of Bahrain, where this study was conducted, have been launched since the 1990s through several projects at different levels. Integrating information and communication technology (ICT) in the field of education and training is also part of Bahrain's Economic Vision 2030 (Abdul Razzak, 2018). The King Hamad Schools of the Future Project (KHSFP), launched in 2003 and the UNESCO King Hamad Prize in 2005, among many other government initiatives, deserve special mention for nurturing a knowledge-based economy and better job prospects for sustainable communities. In higher education in Bahrain, hybrid learning was adapted by only one organization with 25% face-to-face teaching and learning. E-learning practice in traditional universities relies heavily on learning management systems like Blackboard or Moodle (Abdul Razzak, 2018).

Despite some noteworthy success stories, e-learning in Bahrain schools as well as in higher education faces serious challenges in terms of updated ICT literacy, ICT-based pedagogical training, and the availability of culturally relevant teaching software in the native Arabic language. Moreover, inadequate documented research on e-learning and a lack of alignment between the overall organizational ICT infrastructure and strategies of the education system make the task more daunting (Abdul Razzak, 2018; Ghanem, 2020). To fill this research gap, the present study examined the effectiveness of integrating educational technology using ZipGrade to conduct formative assessments in face-to-face classrooms and provide immediate feedback. It attempted to achieve learning outcomes by reinforcing instruction and promoting the quality of teaching and learning in higher education.

During the transition from face-to-face learning to e-teaching and e-learning due to COVID-19, the need to offer immediate feedback to support better achievement, positive motivation, and self-esteem were emphasized in the study conducted in the same locale by Al-Hattami (2020). The study examined the effectiveness of e-teaching and e-learning in general with a focus on the implementation of e-assessments in particular. A sample of 118 teachers and 539 students responded to two independent questionnaires analyzed quantitatively. The instructors who participated in the study reported using Kahoot (31%), Google Forms (17%), Socrative (7%), Quizlet (5%), Near Pod (1%), and Mentimeter (1%). The findings support the use of e-learning and technological applications for formative assessment. However, face-to face communication was preferred for summative assessment (Al-Hattami, 2020).

ZipGrade, one of the apps approved by the Ministry of Education in Bahrain[1], is known to be an effective and efficient tool and popular among teachers. Several research studies have reported incorporating it for instant data collection and analysis purposes (Celik & Kara, 2022; Louis, 2016; Serrano, 2023; Suhendar et al., 2020). For teachers, it makes grading effortless without requiring a Scantron machine or sheetfed scanner. Useful data on multiple-choice question assessments can be captured, stored, and quickly reported, offering students immediate feedback on written tests (Cortez et al., 2023).

Once shown to be accurate and efficient, this tool can be recommended to faculty in higher education for its efficacy and time-saving reliability in grading objective type/multiple-choice questions, while also ensuring students receive timely feedback on their attempt.

Literature Review

Although the history of educational technology is about a hundred years old, academic research that centred on the impact of technology for teaching and learning has been limited. This literature review focuses mainly on the use of recent digital technology in two forms of assessment – formative or summative. The review covers the application of technological tools in class, related similar technological innovations, action research, and some perception studies. In addition, it describes digital devices in formative assessments and evaluation studies; specifically, the information collected pertaining to the benefits and challenges of using ZipGrade.

Recent developments and their implications in assessment practice in math education are reviewed and analyzed by Bhuvaneswari and Elatharasan (2019) in a paper which was presented at the National Conference on Technology Enabled Teaching and Learning in Higher Education, held in India. The article enlists the strengths and limitations of five assessment tools namely: Kahoot, Quizlet live, Socrative, Nearpod, and ZipGrade. It further concludes that qualities like persistence, self-regulating behaviour, participation, and a special enthusiasm for learning are developed through assessment tests.

Şimşek et al. (2017) use document analysis of written and visual materials containing information to discuss the assessment and evaluation process. Şimşek et al. discuss potential usage of Kahoot, Plickers, Electronic Based Assessment, ZipGrade, and GeoGebra in the preparation and evaluation of exams. The study enlists developing technological pedagogical content knowledge of educators; more active participation; creating an interesting and conceptual learning environment saving time in assessment as the potential benefits of using software in math assessment and evaluation. Further, it recommends the integration of ICT in teacher training institutes and in-service training programs.

A study presented at the 24th International Conference on Intelligence User Interface (IUI'19 – Companion) by Wagstaff et al. (2019) aimed at exam grading using a mobile camera. Conducted at the

[1] digitaltoolsguidance/moe/2020; digitaltoolsguidance/version2/moe/2022

University of California, Los Angeles (UCLA), it offered a digital solution called Snaptron, an education tool for exam grading using machine learning and OMR. Teachers can take a picture of students' responses on an assessment, send it to a server for grading, and instantly receive the results. The survey study implemented grading scripts for four different exam formats such as bubble style, ZipGrade style, one-word free response, and mixed response. The article concluded that Snaptron was a scalable product for multiple exam formats and offered a low-cost, fast, and strong alternative to traditional exam grading.

Blattler et al. (2023) introduced a "One-shot grading" automatic answer sheet checker at the IEEE International Conference on Industrial Engineering and Engineering Management (IEEM). The system utilizes machine vision and image processing to grade multiple-choice and true/false questions. It offers adaptability to different examination weights and formats. Compared to ZipGrade as a standard, the reliability and accuracy of this innovative design was confirmed and highlighted to a superior level.

The effective twinning of formative assessment with summative in a West Texas history class by examining students' perspective was emphasized through action research by Goodenough (2019). Data were collected through various sources such as: distributing surveys, conducting six student interviews and one administrator interview, and observing student conversations. Goodenough (2019) found the process unique and successful in many ways in achieving the school's goals. The outlined benefits were an opportunity to improve grades from one test to the next, relearn information, and master the concepts. ZipGrade was used for formative and summative assessments provided instantly to students and additionally for item analysis examine focused reviews between the two assessments. Another action research conducted on 15 teachers in the Philippines by Cortez et al. (2023) revealed that ZipGrade is more useful to teachers in checking students' long tests and unit tests, and aids in analyzing the result of assessment and increasing the speed of time spent in correcting student responses.

Perrotta (2013) explored student and teacher perspectives using survey data from 683 teachers in 24 secondary schools across the United Kingdom to analyze the factors influencing how the benefits of digital technology are being experienced. The study pointed to the need to develop a more rounded picture of the relationship(s) between the social contexts that surrounded schools, teachers, and technology use.

Hendrith (2017) studied the professional development of primary school teachers. The selected teachers were trained through a technology integration workshop and later assisted with implementation through follow-up. An increase in teacher confidence and implementation along with a positive attitude were reported in the study. Similar results have been reported in terms of educators gaining confidence through a greater number of hours spent on technology training in another study conducted by Atkins and Vasu (2000).

Ningsih and Mulyono (2019) also investigated teachers' use and perception of digital assessment resources in primary and secondary school classrooms in Indonesia by administering a self-reflection survey to 18 educators using Kahoot and ZipGrade for assessment. The findings revealed a positive attitude towards the applications for their practicality, fun learning environment, instant scoring, and direct feedback. However, the respondents also reported challenges about policy on in-school mobile phones and inadequate timely technical support for teachers.

A case study of 24 senior preservice teachers by Özpınar (2020) examined their perception of Web 2.0 technology-based tools used for assessment, namely: Plickers, Kahoot, Edmodo, and ZipGrade. The teachers had generally positive opinions about all the tools in assessing students' knowledge and progress emphasizing the need for reliable Internet and availability of technical devices. Out of the four tools, ZipGrade was rated as the most time-saving tool (Özpinar, 2020).

Perceptions of both teachers and students were analyzed in an assessment of learning outcomes conducted through ZipGrade in a quasi-experimental Indonesian vocational school study by Suhendar et al. (2020). The experience using the ZipGrade application was favourable in finding the work easier and more simplified. It provided information on the results of the validity analysis, the level of difficulty of the questions, and the distinguishing features of each item. Such results can further enhance teachers' understanding of student needs and abilities to perform better in the subject (Suhendar et al., 2020).

Lookadoo et al. (2017) explored the role of educational video games in formative and summative assessments of 172 randomly assigned undergraduate Biology students in an experimental study conducted in the United States. The findings showed an increase in post-test knowledge after playing in all game conditions. It was important to note in this digital device study that formative assessment reflected both better learning and engagement.

Elmahdi et al. (2018) investigated the effectiveness of a classroom response system introducing Plickers for formative assessment. Adopting a descriptive mixed method design, the researchers collected data from 166 students at Bahrain Teachers College using a questionnaire. The findings emphasized the benefits of the digital tool such as improved student participation, saving on learning time, equal participation opportunity for all, and a fun and exciting learning environment. The study recommended the integration of Plickers in classroom teaching for formative assessment to help support learning.

In a more recent study, reported from the University of Missouri, Columbia, Muslu and Siegel (2024) assert that assessment feedback is an essential way to promote student learning. Using typological data analysis, the respondents rated ZipGrade high in visibility dimension in terms of monitoring the progress of both individual students and the entire class (Muslu & Siegel, 2024). The teacher had immediate access to the statistical information and individual student responses. The study concluded with promoting the viewpoint that a balanced approach to technology-based assessment was the most effective way to assess learning outcomes where apps become complementary tools leading to innovations in pedagogy.

The above-mentioned research introduced mobile technology features and educational applications. Some also report instruments developed to evaluate applications geared towards student learning, but there is no instrument to evaluate teacher resource applications. The five-point evaluation or rating on App Store or Google Play does not explain the meaning of the points/stars for each application. This significant observation was reported by Cherner et al. (2016) where they combined research related to designing instructional technologies and the best practices for supporting teachers. The information obtained was used to construct a comprehensive rubric for assessing teacher resource applications. Cherner et al. (2016) meticulously presented the need for a rubric, the process to create such a rubric, the presentation of said rubric, and a discussion on its merits.

ZipGrade – Benefits and Challenges

This study focuses on ZipGrade in the context of formative assessment. The literature review also provides specific and comprehensive details about this app. The integration of digital and physical assessment methods offers a blend of benefits and challenges. According to Cherner et al. (2016), one key strength of this approach is its ability to combine digital and physical elements to enhance the assessment process. It provides instant feedback to students, which is facilitated by using phones as scanners. This saves both printing time and effort and allows for the reuse of materials, thereby significantly shortening the time required for assessment and evaluation.

The feedback dimension of the studies on ZipGrade emphasizes visibility, where students receive their individual scores promptly. This immediate feedback mechanism is beneficial for both students and teachers, as it allows teachers to access not only individual scores but also statistical information for item analysis, facilitating a deeper review of student performance (Cherner et al., 2016; Muslu & Siegel, 2024).

The rubric rating for ease of use, classified under Domain C (Design) as dimension C2, highlights the system's user-friendliness (Cherner et al., 2016). Teachers can navigate the system with minimal guidance, with clear, thoughtful icons and visual aids that symbolize complex functions. This design enables them "to understand the visual components on screen, identify interactive buttons, make selections, and execute various tasks" (p. 126), offering a significant advantage over manual scoring methods or the use of systems like Scantron.

However, this method is not without its limitations. The need to physically print answer sheets remains a constraint. The system's preference for multiple-choice questions may limit its applicability across various assessment types. Digital grading systems might make errors, and issues with inappropriate scanning can lead to test items not being scored. Additionally, challenges such as school infrastructure, policies regarding technology and mobile phone availability, teachers' lack of knowledge about the application, and unreliable Internet access can influence its effectiveness (Ningsih & Mulyono, 2019; Özpinar, 2020). The present research study aims to analyze the effectiveness and reliability of ZipGrade as a formative assessment tool in a face-to-face classroom administering multiple-choice question tests. The research questions addressed through the study are:

1. Is ZipGrade an effective and reliable tool to be used for assessment?
2. What is students' perception about using ZipGrade for marking their work?
3. What are the observations of educators who have used ZipGrade for classroom assessment?

Technology-Based Assessment – A Conceptual Framework

The Technological Pedagogical Content Knowledge (TPACK) framework explains how teachers can effectively integrate technology into their teaching practices. Originally developed by Mishra and Koehler (2006), TPACK addresses the dynamic interplay between three core domains: Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK). This interaction allows teachers to deliver content effectively using technology while employing sound pedagogical methods. TPACK serves as a bridge between research and pedagogy, highlighting the complex relationships that drive technology integration in education (Arora and Arora, 2021; Palanas et al., 2019).

This study explores the use of ZipGrade as a technology-based assessment tool. The TPACK framework guides how educators not only use technological tools (TK) but also make informed pedagogical choices (PK) while delivering subject-specific content (CK). This tool helps automate the grading process and provides data-driven insights into students' learning progress. The intersection of these three domains in the TPACK model helps explain how teachers can effectively use ZipGrade to improve student learning outcomes, offering a transferable framework for other educators. Technology-based assessment tools like ZipGrade fit within the TK component of TPACK but require careful alignment with PK and CK to be effective. The TPACK framework highlights that simply using a tool is insufficient; educators must understand how to implement it to foster deeper learning.

ZipGrade serves as more than a grading tool. It enables educators to conduct assessments that provide immediate and accurate feedback, making the process more efficient. By leveraging the data provided by the tool, teachers can identify gaps in students' understanding and apply targeted teaching strategies (PK) that are informed by the assessment results. This process aligns with formative assessment practices, where the goal is to improve student performance through timely intervention.

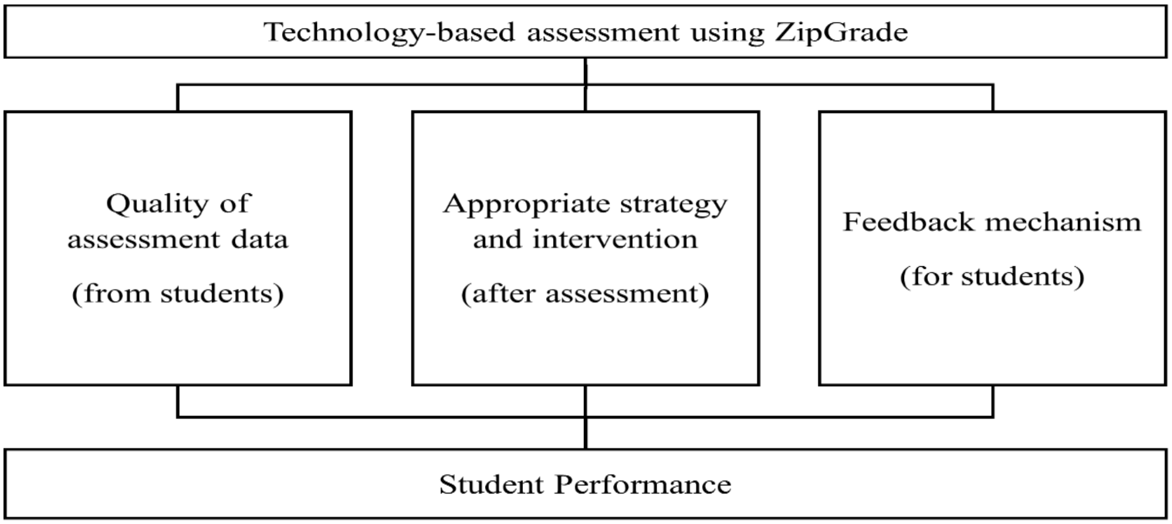
Moreover, the feedback mechanism is a critical component of this framework. Research on formative assessment emphasizes the importance of feedback in guiding learning (Hattie & Timperley, 2007). In technology-based assessment, this feedback is delivered more quickly and with greater accuracy, allowing for immediate instructional adjustments. Therefore, ZipGrade not only supports efficient assessment but also enhances pedagogical practices by providing actionable insights into student learning.

The adoption of formative assessment theory complements the TPACK framework in this study (Black & Wiliam, 1998). Formative assessment emphasizes ongoing evaluation to monitor student learning and provide feedback that can improve teaching and learning in real-time. This theoretical underpinning makes the observations from the use of ZipGrade transferable to other classrooms because it is grounded in well-established educational practices.

By incorporating both TPACK and formative assessment theory, this study creates a conceptual framework that links technology, pedagogy, and assessment. This framework underscores the importance of valid and accurate data from technology-based assessments and the role of feedback mechanisms in promoting effective teaching strategies and interventions (Figure 1).

Figure 1

Conceptual Framework of the Research



Method

Data were collected in the 2023-2024 academic year. A set of formative assessment tests with multiple-choice questions were prepared for shortlisted courses based on a portion of the curriculum. These tests were administered in classrooms and marked using ZipGrade. Student scores were shared with them immediately. This process was repeated with another set of formative assessment tests from a different portion of the curriculum at least three to five times for each group of students to check for the consistency of the results. At the end of the semester, students responded to a questionnaire about their perception of the ZipGrade tool, its utility and effectiveness. The content validity was checked by three experts in educational assessment and reliability was found to be 0.87. The data were analyzed descriptively (mean and standard deviation) using SPSS program.

Sample

The study sample was comprised of 63 fourth year students (18 males and 45 females) in the first semester of the academic year. Respondents were preservice teacher candidates from a teachers' college. Besides the students, the two authors of the present study were the educators who administered ZipGrade application in their respective sections.

Steps to Use ZipGrade

The ZipGrade application is straightforward to use. Teachers print test forms from the ZipGrade website and create class lists in the specified format. They then fill in the correct answers for their tests in the application. Students complete the multiple-choice forms and submit them for marking. Using the ZipGrade application and the built-in tablet camera, the system automatically analyzes student answers and records the grades in a digital gradebook.

This scoring process emphasises the system's efficiency and advantages over traditional scoring methods. In addition, the use of intuitive buttons and icons in the application make significant improvement when compared to long hours spent manually grading (Cherner et al., 2016).

Instrument

A questionnaire was developed and used to collect student perceptions about using ZipGrade for marking. It was designed to assess user experiences and opinions of the ZipGrade grading tool, widely utilized for evaluating multiple-choice tests. Beginning with background information, it collected demographic details and previous exposure to ZipGrade, including program level, gender, familiarity, and usage history with the tool.

Before distributing the survey questionnaire, the purpose of the research and its voluntary participation were explained to the students. Students were assured that information provided would be confidential and used for research purposes. A consent letter with a thank you note was printed on the backside of the survey form providing contact details for the two investigators, in case of any questions/ concerns.

The survey was comprised of nine statements for respondents to rate their level of agreement on a five-point scale, ranging from "Strongly Agree" to "Strongly Disagree." These statements explored various facets of the user experience, such as the enjoyment, excitement, and satisfaction derived from using ZipGrade, the preference for immediate scoring versus detailed feedback, intentions regarding future use for student motivation, and perceptions of the tool's ease of use and learning curve. An open-ended question for additional comments was also provided, offering participants the opportunity to share insights or suggestions beyond the structured queries.

As English is the second language of the target group, the research tool was translated into Arabic, and the rating statements were provided in both English and Arabic to ensure clarity and comprehension. Student scores on formative assessments of a portion of the courses taught by the researchers were used to examine the students' performance. Since the application gave the instructors a quick distribution of marks for individual students and the whole class, it also provided them with an opportunity to clarify student doubts and revise topics. Qualitative observations were made throughout the process of conducting formative assessments and reteaching portions from the curriculum where student scores were low.

Findings

The survey in this study exclusively targeted participants from the "Year 4" program, capturing a diverse gender distribution but, coincidentally, with a higher female representation. A significant majority of the respondents (50) were introduced to ZipGrade for the first time as part of this survey. Additionally, a large portion of the group has known about the tool for "less than a year," which aligns with the high number of first-time introductions. Regarding personal use of ZipGrade, most respondents (59) had not used ZipGrade themselves, with only 4 indicating personal usage.

This distribution suggests that ZipGrade is a relatively new or previously underutilized application among this group of respondents. The skew towards non-use and new introduction could influence perceptions and experiences reported in other parts of the survey, highlighting potential areas for educational focus or resource allocation to enhance familiarity and engagement with ZipGrade as an educational tool.

Table 1

Demographic Details and Background Information

Variable	Level	Count	Percentage
Gender	Female	45	71.43%
	Male	18	28.57%
First time introduced to ZipGrade	Yes	50	86.21%
	No	8	13.79%
Time known this tool	Less than a year	50	78.13%
	More than 2 years	11	17.19%
	More than a year	2	3.13%
Used ZipGrade yourself	Yes	4	6.35%
	No	59	93.65%

The descriptive statistics results generally indicate a positive perception of ZipGrade among respondents. The mean ratings for all aspects related to the use of ZipGrade for tests fall well above the midpoint of the scale, suggesting that participants found the tool enjoyable, exciting, and fun to use. Specifically, the enjoyment of taking tests with ZipGrade answer forms and the ease of learning the ZipGrade format both received the highest mean ratings of 4.57, accompanied by relatively low standard deviations (0.69 and 0.71, respectively), indicating a strong consensus among participants about these aspects (Table 2).

Similarly, the satisfaction with how tests were administered using ZipGrade and the ease of use of the ZipGrade format also scored high (mean of 4.51 and 4.56, respectively), further underscoring the tool’s positive reception. Despite the overall enthusiasm, the intention to use ZipGrade for formative assessments in the future received the lowest mean rating (4.30), though still significantly positive, with a slightly higher standard deviation (0.93), suggesting somewhat more variability in participant intention to use the tool in future teaching practices.

Table 2

Descriptive Statistics of the Responses

Statements	Mean	Standard Deviation
Enjoyment of taking tests using ZipGrade forms	4.57	0.69
Excitement to use ZipGrade answer forms	4.52	0.78
Fun in using ZipGrade answer forms	4.35	0.77
Satisfaction with the way tests were administered using ZipGrade	4.51	0.82
Preference for detailed feedback from teachers on multiple-choice questions instead of marks	4.37	0.89
Intention to use ZipGrade for formative assessments in the future	4.30	0.93
ZipGrade format is easy to use	4.56	0.69
ZipGrade format is quick to learn	4.57	0.71

Respondents also expressed a preference for receiving detailed feedback from teachers on multiple-choice questions over mere marks (mean of 4.37). This indicates a desire for more formative feedback to support learning, which ZipGrade can facilitate by providing immediate test results.

Responses to the open-ended question for additional comments were positive and included frequent comments about the application as "interesting", "easy", and "useful". There were some who favored the app for its "immediate feedback" and others found the feedback with correct answer given beside an incorrect answer as "constructive". A couple concerns were raised in terms of giving immediate feedback to a class of over 30 young students, and the feedback on an answer sheet which had overwriting, and some responses were changed. It was noted by the app administrator that the answer sheets with changed answers or with writing on the margins did not get scanned. In such cases, the students were given another blank response sheet to redo the assessment and record their answers clearly.

Overall, findings suggest that ZipGrade is well-received by student users who appreciate its user-friendly and engaging format. The slight variability in the intention to use ZipGrade for future assessments suggests that while respondents recognize its value, there may be factors influencing their ability or desire to adopt it more broadly in their teaching practices. This positive feedback, combined with a preference for detailed feedback, points towards a constructive reception of technology-enhanced learning tools that facilitate immediate feedback and engage students in the learning process.

Educator Observations and Insights

The authors of this study were the faculty who administered the application in their respective sections of year four classes. One is a frequent user of ZipGrade in classrooms and is familiar with it. The other is a first-time user who received a few hours training in tailoring the multiple-choice questions in ZipGrade format, preparing the answer key, and doing a few trials before using the application in the classroom. After the initial one-time investment in setting up the app on the mobile phone, creating the answer keys and printing the answer sheets, the swift outcome observed in the classroom was found to be fascinating and impressive.

An important insight gained was that students seemed more comfortable with such frequent formative assessments with immediate feedback as compared to traditional end-of-topic review quizzes. With the immediate feedback received and the item analysis of question items through ZipGrade, the components on which students scored low were discussed right away. Although the gains in subsequent formative assessments were not analyzed quantitatively, students' improved competence in tackling assessments with multiple-choice questions was evident from the boost in their confidence. The increase in understanding with ease is consistent with the findings of Suhendar et al. (2020). In addition, with this format the formative test questions did not need to be printed separately for all the sections, and the same question papers could be handed to another section with a blank answer sheet separately.

Discussion

The findings provide valuable insights into the effectiveness and reliability of ZipGrade as a formative assessment tool in the classroom setting. Consistent with previous literature on digital tools for assessment, this study highlights the strengths of ZipGrade, particularly its ability to provide instant feedback, saving time and effort in grading; its ease of use facilitated by intuitive design and visual aids. These findings resonate well with the advantages of ZipGrade discussed by several researchers (Cherner et al., 2016; Cortez et al., 2023; Goodenough, 2019; Ningsih & Mulyono, 2019; Özpinar, 2020; Palanas et al., 2019; Suhendar et al., 2020). The majority of participants reported a positive experience with ZipGrade, emphasizing its potential to enhance learning outcomes by providing immediate results and enabling a more engaging assessment process. Action research by Goodenough (2019) on student perspectives on both formative and summative assessments emphatically supports the scope for improvement in student scores and conceptual understanding in subsequent tests. Muslu and Siegel (2024) reinforce the potential to support the reflection and action dimensions while discussing the guiding impact of feedback through digital application affordances which include ZipGrade.

This study also shed light on limitations associated with the tool. The requirement to physically print answer sheets and the tool's inclination towards multiple-choice questions may limit its broader applicability across different assessment types. Furthermore, issues such as potential inaccuracies in digital grading and challenges related to school infrastructure, policy on technology use, and varying levels of teacher familiarity with the application were noted. These challenges underscore the necessity for comprehensive support and training for educators, alongside infrastructural improvements, to fully leverage the benefits of ZipGrade in educational settings. The need for teacher training is supported through studies conducted by Suhendar et al. (2020) and Cortez et al. (2023). The need for basic infrastructure like Internet access and technological devices to use Web 2.0 tools has also been emphasized by preservice teachers in the study by Özpinar (2020) and primary school teachers in the study by Ningsih and Mulyono (2019).

Survey responses also indicated a strong preference among students for receiving detailed feedback on their assessments, beyond the scores. This resonates with an Indonesian study in which university students stated insufficient feedback as one of the drawbacks of formative assessment (Taufiqullah et al., 2023). This suggests a critical opportunity for educators to use tools like ZipGrade not only for efficiency in grading but also as a mechanism for delivering constructive, formative feedback that can further student learning and understanding.

ZipGrade provides information on the results of validity analysis, the level of difficulty of the questions, and the distinguishing features of each item on the assessment (Suhendar, 2020). With all these provisions, the educators have an opportunity to impart quality education. Students also have an opportunity for individual learning and assessing their understanding of course content assuming an independent role using such instruments. This is precisely "the recommended guideline" (p. 109) for quality assurance of e-learning in higher education programs in Bahrain within the student assessment dimension (Abdul Razzak, 2022).

Conclusion

ZipGrade as a formative assessment tool represents a significant step forward in integrating technology into educational assessment practices. This study confirms the utility of ZipGrade in providing a user-friendly, efficient, and engaging method for conducting formative assessments, aligning with the broader goals of e-learning initiatives in Bahrain and beyond. The positive reception of ZipGrade by both students and educators highlights its potential as a transformative tool for formative assessment, contributing to the creation of a more interactive and responsive learning environment.

To maximize its benefits, it is essential for educational institutions to address the limitations identified in this study, including the need for physical infrastructure, teacher training, and policies that support the use of technology in assessment. Palanas et al. (2019) recommend the formulation and implementation of a local policy on digital evaluation. Moreover, educators are encouraged to complement the use of ZipGrade with substantive feedback, leveraging the tool's capabilities to enhance student learning and performance comprehensively.

In conclusion, ZipGrade offers a promising avenue for enhancing the efficiency and effectiveness of formative assessments in classrooms. By addressing its current limitations and focusing on the broader educational context, educators can further harness the potential of this tool to support student learning, and the achievement of course intended learning outcomes. As technology evolves, ongoing research and adaptation will be crucial in ensuring that digital assessment tools like ZipGrade remain relevant and effective in meeting the changing needs of educators and students alike.

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