Exploring Pedagogies & Strategies for Integrating Adaptive Learning Platforms: A Case Study of a High School in Hong Kong

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ABSTRACT

This paper explores the pedagogical approaches teachers employ and the strategies that school leaders implement to promote the use of an Adaptive Learning Platform (ALP) in a high school in Hong Kong. It assesses how such an AI-powered platform can support teachers in enhancing student engagement and learning outcomes. The study employs a case study methodology to identify the factors influencing the incorporation of ALP. Qualitative data were collected through teacher interviews, and an in-depth analysis was carried out to identify effective pedagogies and strategies for implementing adaptive learning. The findings of this study underscore the significance of supportive school leadership that encourages teachers to embrace ALP as a tool for promoting student learning. Additionally, effective implementation of ALP necessitates a shift in pedagogical practices from traditional teacher-centred approaches to more student-centred strategies. The study concludes that the integration of ALP into teaching practices can boost student engagement and elevate the quality of learning outcomes. In summary, this research contributes to understanding the successful implementation of ALP in high schools, emphasising the critical roles of school leadership support and the adoption of student-centred pedagogies. The findings provide valuable insights for educators, administrators, and policymakers interested in utilising ALP to improve student learning outcomes.

CCS CONCEPTS

• **Applied computing** → Education; Interactive learning environments.

KEYWORDS

Adaptive learning system, Pedagogies, Assessment for learning, AI in Education

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1 INTRODUCTION

Traditional teaching and learning practices, often criticised for their one-size-fits-all approach [1], tend to focus on the 'average' student, often leaving those with differing mastery levels inadequately addressed. Despite the widely acknowledged benefits of personalised and adaptive learning in 21st-century education, such practices face implementation hurdles in many Hong Kong schools due to current classroom realities.

Digital technologies are forging new pathways for personalised instruction, becoming an important addition to modern teaching and learning practices. While these technologies offer a myriad of opportunities, many teachers are yet to fully embrace them. Spurred by the Covid-19 pandemic [2] and fast-paced advancements in AI, adaptive learning platforms have emerged as a promising digital technology. They actualise personalised and adaptive learning by providing tailored content, feedback, and opportunities for skill mastery, while also guiding instructional decisions and promoting self-regulation among students [3–5].

However, successful integration of these adaptive learning platforms in classrooms heavily relies on effective pedagogy, a topic currently under-explored in existing literature. Effective integration isn't a straightforward task—it calls for a thoughtful evaluation of pedagogical goals, student needs, and available resources. Teachers must assess the capabilities of digital technologies and devise pedagogical strategies that align with their teaching objectives and students' learning needs [6]. Moreover, the role of school leaders in facilitating this adoption process is equally significant.

This study aims to fill this gap by examining teachers' pedagogical approaches in integrating adaptive learning platforms into their teaching. In addition, it investigates the strategies employed by school leaders to enable and support teachers in incorporating these platforms into their classrooms.

2 LITERATURE REVIEW

2.1 Assessment for Learning

Assessment is a crucial component of the teaching and learning process. Summative assessment, also known as assessment of learning, aims to measure and report students' learning outcomes [7]. On the other hand, formative assessment or assessment for learning focuses on monitoring the learning process's quality and providing continuous feedback to guide teaching and learning. This process entails interactive co-regulation of learning and active knowledge construction [8] and is considered a pedagogical practice for teaching [9]. Effective assessment practices have been shown to improve the quality of learning and enhance academic outcomes [10]. Implementing assessment for learning strategies in the classroom can also promote students' self-regulation [11–13].

Previous research has demonstrated the crucial role of teachers in shaping the effectiveness of assessment for learning [14, 15]. Several teacher-related factors have been identified to influence the implementation of assessment for learning. These factors include intrapersonal factors such as teachers' understanding of the distinction between assessment for learning and assessment of learning [16], teachers' agency in facilitating assessment for learning [17], and teachers' beliefs about teaching and learning [18]. Interpersonal factors have also been identified as critical to the successful implementation of assessment for learning, particularly the trusting relationship between teachers and students [19]. These findings highlight the importance of considering various teacher-related factors in implementing effective assessments for learning practices.

Through digital tools, students' interactions with online learning tasks can be recorded and analysed, providing valuable insights into learning behaviour patterns and needs and thus opening up new possibilities for assessment for learning [11]. The real-time nature of data capture and reporting afforded by online tools offers teachers timely updates, enabling them to provide targeted and personalised feedback to students. Shute and Rahimi [20] reviewed computer-based assessments for learning and found that they provide timely feedback, keep students engaged, and improve their ability to self-regulate their learning. By analysing data generated by students' interactions with online tasks, computer-based assessment for learning can enhance personalisation in learning, enabling teachers to tailor their instruction to better meet the needs of individual students [20]. Barana, Marchisio, and Sacchet [21] developed an online assessment system for Mathematics and found that its implementation can effectively enhance students' mathematical understanding and self-assessment skills. These findings demonstrate the potential of computer-based assessment for learning to improve student learning outcomes, particularly in subjects like Mathematics, where assessment is crucial for measuring student progress. Building on these successes, Timmis, Broadfoot, Sutherland, and Oldfield [22] argued that technology could significantly change assessment practices, leading educators to rethink assessment purposes concerning student learning and develop new assessment methods for meaningful learning in the digital age.

2.2 Adaptive Learning Platforms

Adaptive learning platforms have emerged as an emerging and noteworthy technology in teaching and learning, as recognised in the *2020 Horizon Report* [23]. These platforms can be technology-based programs that adapt to the learner's responses and interactions with the program [3, 4, 24]. They are particularly well-suited for assessment for learning purposes, continuously assessing a learner's understanding and generating supportive content until a specific learning goal is achieved. Additionally, some adaptive learning platforms can capture data through learning analytics [24], providing students with assessments, instructional content, hints, and feedback on their progress as they acquire or reinforce mathematics skills. Others emphasise immediate feedback, enabling students to master skills before advancing and collecting data on student performance. Additionally, some adaptive learning platforms focus on providing immediate feedback, allowing students to master skills before moving forward while simultaneously collecting data on student activities [25].

Adopting adaptive learning platforms has been observed to enhance the academic achievement of students [6]. Numerous studies have established that students exhibit favourable attitudes towards utilising adaptive learning platforms [26, 27]. In particular, various investigations have reported that students derive satisfaction from the unique features of adaptive learning programs, such as instant feedback provision, personalised content, and the flexibility to work at their pace [25, 28, 29]. Additionally, research findings indicate that students appreciate the ability to customise their learning experience and optimise instructional time using various pedagogical approaches [30].

Adaptive learning platforms have been shown to have potential benefits for students, but the effectiveness of their implementation is heavily dependent on the pedagogical strategies employed by teachers. Ng and Fergusson's [31] research indicates that successfully integrating adaptive learning technologies hinges on teachers' ability to assimilate new technologies and content knowledge into their pedagogical frameworks. Thus, it is essential to understand teachers' effective pedagogies as they incorporate adaptive learning platforms. These findings emphasise the need for educators to develop a deep understanding of these tools and align their implementation with established pedagogical approaches to achieve optimal learning outcomes.

2.3 TPACK

The TPACK model, a conceptual framework proposed by Mishra and Koehler [32], delineates the essential components of teachers' knowledge: content, pedagogy, and technology. This framework extends Shulman's [33] Pedagogical Content Knowledge (PCK) model, highlighting the knowledge necessary for effective teaching. The TPACK model emphasizes the intersection of three knowledge types: technology knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK), presenting a novel perspective on the integration of technology in teaching.

Depicted as a Venn diagram with three overlapping circles, each circle in the TPACK framework represents a distinct form of teacher knowledge. Teachers must grasp how these three knowledge domains intersect to enable effective teaching with technology. Beyond PCK, the TPACK model introduces technological content knowledge (TCK), technological pedagogical knowledge (TPK), and TPACK [34].

Each teaching situation requires a unique combination of these factors, implying that no one-size-fits-all solution fits every teacher, course, or teaching approach. Rather, effective solutions rely on a teacher's flexibility in navigating the spaces defined by the content, pedagogy, and technology elements and understanding their complex interactions in specific contexts.

Tseng, Chai, Tan, and Park [35] pointed out that TCK and TPCK are typically tied to practical considerations. Consequently, Mishra [36] refined the TPACK diagram, replacing the outer dotted circle labeled "Context" with "Contextual Knowledge," reflecting the organizational and situational constraints within which teachers operate (see Figure 1). Koh and Chai [37] further suggested that in addition to mastering TPACK, teachers also need design knowledge

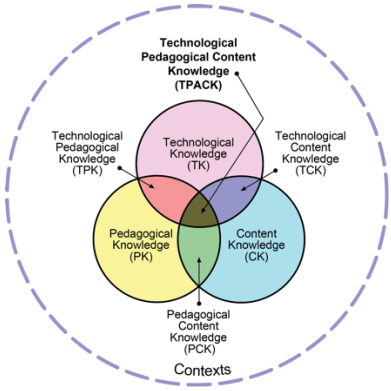

Figure 1: The revised version of the TPACK framework (Mishra, 2019), reproduced by permission of the publisher, ©2012 by tpack.org (http://matt-koehler.com/tpack2/wp-content/uploads/2013/08/TPACK-new.png)

to plan and execute lessons that effectively incorporate technology to enhance student learning.

2.4 Digital Leadership

Defining the essential characteristics of digital leadership in schools is an ongoing discussion in educational research, with some commonalities across various studies. For instance, Van Wart, Roman, Wang, and Liu [38] suggest that strong digital leadership encompasses the ability to effectively select and use ICTs for personal and organisational purposes. Similarly, Preston et al. [39] identify it as *"the effective promotion and integration of technological learning and literacy into and within [educational] environments"* (p. 991). Garcia and Abrego [40] regard strong digital leadership as being familiar with technology, using information retrieval, communicating with stakeholders, and managing resources. Chang's [41] Principals' Technological Leadership Instrument rates digital leadership based on various perspectives, such as vision, professional development, infrastructure support, evaluation, and communication. Zhong [42] further elaborates on the importance of digital leadership in providing guidance and direction in integrating technology into educational practices. Therefore, it is crucial to clearly understand digital leadership's constituent elements to promote its effective implementation in schools.

In the context of schools, effective digital leadership is recognised as having a significant and immediate impact on teacher practice [43]. School leaders occupy a unique position in which they are capable of responding to challenges and driving change [44–46]. Kozma [47] contends that digital leadership is essential for successfully implementing technology in schools, and research indicates that it fosters and enhances digital teaching and learning [48]. Principals, in particular, play a critical role [49, 50]. According to Chang [41], principals' attitudes and knowledge regarding technology directly impact teaching effectiveness and teachers' capacity to integrate technology into their teaching. Raman, Don, and Kasim [51] further attest to the positive effects of principal leadership on technology use in teachers' classrooms. Principals serve as role models in the school's daily life and shape teachers' behaviour through their interactions.

Effective school leaders play a crucial role in driving technology integration by communicating the importance of change to key stakeholders and educators [40]. By raising awareness of technology's potential to transform learning experiences, school leaders can help create a shared vision that rethinks and redesigns learning environments [40]. Additionally, successful school leaders establish conditions that facilitate the use of technology in pedagogy. They motivate teachers to adopt technology in teaching by providing explicit preferences, mandates, reward systems, and incentives [52, 53]. Furthermore, they allocate resources, such as reserve funding, to invite university professors and industrial experts to conduct sharing sessions, which promote the integrative use of technology in schools. The effectiveness of school leadership is often measured by the extent to which the principal is open to collaboration and distributes leadership responsibilities [54]. School leaders who adopt a contextual approach recognise no universal formula for technology adoption. Instead, they consider their school community's specific needs and culture to devise effective technology integration strategies. As such, some leaders permit teachers to make autonomous decisions with their teaching practices, especially when they may imply a more innovative use of technologies with pedagogical gains. Stakeholder engagement and feedback loops are also essential for effective leadership, as they amplify the scope of technology infusion in teaching and learning and allow heightened innovation levels. This openness contributes to developing a shared vision and nurturing a culture of collaboration among teachers of individual disciplines [55]. Strong school leadership can also be reflected in the additional attention given to teacher support and school-level scaffolding, such as the provision of professional development and modelling the use of technology [56]. The scaffolding measures and supports reduce the barrier to innovative teaching and learning with technologies and help teachers to start and progressively make a more significant impact.

2.5 Research Questions

Two research questions guided this study:

- What pedagogies can the teacher use in the adaptive learning platform for mathematics teaching?
- What strategies do the school leaders use to overcome the challenges of implementing the adaptive learning platform?

3 METHODOLOGY

This study utilised a qualitative interview methodology [57] to examine the various factors that influence the integration of an adaptive learning platform among educators. Specifically, this research aimed to explore how teachers effectively utilise their TPACK in integrating an adaptive learning system in schools in Hong Kong.

3.1 The Prototype Adaptive Learning Platform

In 2021, amidst the Covid-19 outbreak, a prototype adaptive learning platform was developed for this research. This system was designed to assist the digital transformation of Hong Kong schools by automating processes that facilitate self-monitored learning and student assessment through quizzes or revisions composed

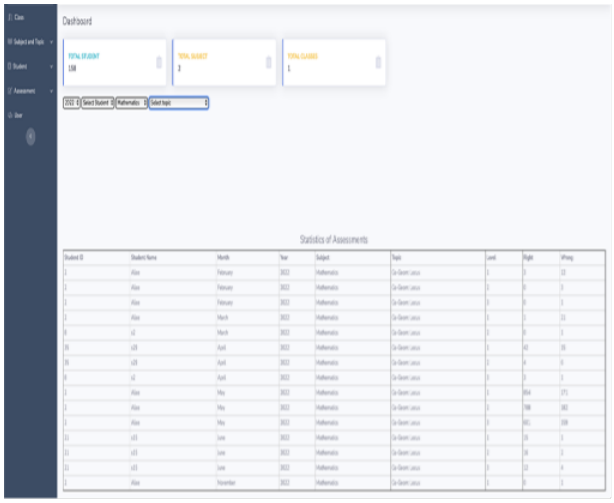

Figure 2: The Dashboard of the Adaptive Learning Platform

of multiple-choice (MC) questions. The platform offers online access via a web-based portal, enabling students to take quizzes or revisions anytime, anywhere, and test their mastery of concepts taught in their classes. The system provides several features for school administrators and students, including maintenance of the question bank, subjects, topics, and students, as well as Question and Answer Display and Data Analysis, among others.

The system is an AI-powered online test system that boasts unique features not commonly found in other school-based online test systems. In traditional systems, MC questions are pre-defined and assigned to a subject and topic by a teacher. These questions are categorised into different levels based on their difficulty, with level one being the easiest and level five the most difficult. The assessment process begins at level one, and the difficulty level increases as the student correctly answers the questions presented. However, if the student answers incorrectly, the difficulty level decreases. Hence, subsequent MC questions are dynamically selected based on the correctness of previous answers. This adaptive mechanism, incrementing and decrementing the question difficulty level, is designed to enhance the effectiveness of the assessment process by catering to each student's knowledge level, promoting deeper understanding of the subject matter.

The question bank functions as a repository that stores MC questions, supplying students with questions for quizzes or revisions. Subject teachers are responsible for contributing MC questions to the system's question bank. Upon input, the system randomly retrieves MC questions from the lowest difficulty level and presents them to students during quizzes or revisions. Additionally, the system records students' answers, related activities, and statistics to generate analytical information for dashboards accessible to both students and teachers/school administrators (see Figure 2 below).

3.2 Case Selection

The selection of cases is a critical task in case studies, a fact which is widely acknowledged [58]. In qualitative research, purposive sampling is commonly employed to select cases relevant to the research question [59]. In the present study, the primary objective of case selection was to optimise learning outcomes for the researchers. Furthermore, literature suggests that cases which are easily accessible and more receptive to inquiry should be selected [60]. Given that the researchers have been involved in a university-supported project involving 30 primary and secondary schools from 2019 to 2022, the schools partnering in this project were considered a suitable pool for case selection. One school willing to adopt the adaptive learning system was selected for the case study. The researchers organised a CoP gathering event to demonstrate the concepts, operations, and effects of the adaptive learning platform to the school. Additionally, the researchers explained the rationale and purpose of the study to the participants and solicited their feedback and input. Based on the feedback received, the researchers fine-tuned their data collection strategies for subsequent events.

3.3 Data Collection

This study employs a qualitative research methodology, wherein the researcher assumes the role of a data-gathering instrument and engages in first-hand involvement with the inquiry process [61]. Specifically, this case study involves interviews with school leaders and teachers to collect data. The interviews primarily focus on understanding how the adaptive learning plan is integrated into the teaching and learning process. To achieve this objective, the school principal, vice-principals, and senior teachers were interviewed to gain insights into the policy and practice of developing and sustaining adaptive learning in the school. The analysis of this phase of the study is primarily aimed at identifying the strategic factors that underpin the school's policy and practices to sustain adaptive learning as a teacher development initiative at the management level. The study identifies the cultural and strategic factors employed by the school to develop and sustain adaptive learning. The study also sought to explain how pedagogies could be internalised, disseminated, and deployed for effective teacher learning, focusing on the best teaching policies and practices for enhancing teaching and learning. For instance, management strategies and teacher professional development policies supported teacher meetings for collaborative lesson planning, post-lesson conferences, and peer lesson observations. The interviews were audio-recorded to enable further analysis.

In this phase, the researcher conducted in-depth, semi-structured interviews with department heads and teachers who participated in the adaptive system to develop TPACK for addressing student learning in a case school. The primary purpose of these interviews was to gain insights into teachers' adaptation to and mastery of the adaptive system. To accomplish this, the teachers were asked to recount their experiences and practices while using the adaptive system with their peers to develop TPACK. Additionally, the interviews sought to evaluate the school policies, strategies, and practices that either supported or hindered their participation in the adaptive system. The teachers were also prompted to reflect on their TPACK learning regarding student learning outcomes. The interview questions were designed to cover various topics, such as school management policies and practices that support teacher learning, collaborative learning experiences of the teachers during

the adaptive system use, and the effectiveness of pedagogical strategies employed. The interviewees were specifically selected based on their direct involvement in the adaptive system, and their insights provide valuable information for understanding the challenges and opportunities associated with using the system in the context of the case school. Overall, the semi-structured interviews conducted by the researcher provided a rich source of data that helped to deepen our understanding of the adaptive system's implementation in the case school, particularly in terms of its impact on teachers' TPACK development. The above-described research approach was guided by previous studies [62, 63] and aimed to obtain a rich and comprehensive understanding of the adaptive system's implementation within the specific school setting.

3.4 Data Analysis and Results

The data analysis in this study is inductive in nature, as patterns and meanings were sought to interpret the data and answer the research questions [64]. Using a grounded theory approach [65], the analysis was characterised by an iterative, emergent, and interpretative process [66]. As an initial step, the raw data were transcribed and translated into English. These data included field notes and memos, school teaching and learning plans, interpretative notes on curriculum content, lesson plans, and interview transcripts from the three case schools. The data were then read and reviewed repeatedly until the researcher was familiar with the participant, the context, the nature of the course, the learning activities involved, and the various scenarios in which the adaptive learning system was applied.

The data were imported into NVivo, a qualitative data analysis software, for descriptive coding. As no pre-determined coding scheme was used, coding was done openly. The researcher interpreted the initial coding during the data reduction process through an analytic spiral, moving back and forth to the data's meaning and identifying recurring patterns inductively [67]. The coding results were assigned conceptual labels to denote the refined analysis results. This process led to the consolidation of analytic themes and contents regarding two levels of analysis. The first level focused on school culture, policies, and leadership, while the second examined teachers' attitudes, pedagogical knowledge, teaching approaches, and student learning outcomes in relation to the research questions.

4 FINDINGS AND DISCUSSION

4.1 Pedagogies for the Use of Adaptive Learning Platform

In answering research question 1, "What pedagogies can the teacher use in the adaptive learning platform?", our study noted a total of three pedagogies, as illustrated below.

4.1.1 Assessment for Learning. The teachers used the system as a dialogic learning tool for learning assessments, aligning with Shulman's [68] conceptualisation of pedagogical practice. Teacher 1 explained, *"I used the report generated by the system to adjust my teaching progression."* The system provides a report highlighting students' strengths and weaknesses in subject knowledge, for example, memorising incorrect formulae, or mistakes like pressing the wrong buttons on a calculator. Teacher 2 reported, *"I used the system to discover the common mistakes and weaknesses of the students (most of the classmates or individual students)."* This enabled him to provide targeted improvement suggestions for individual remedial support. Teacher 3 reported, *"I used the system to alert the students of their common mistakes and spent more time explaining the concept to clarify the importance of memorising formulas"*. All three teachers hoped the system could provide more detailed learning outcomes related to students' common mistakes and offer more multiple-choice questions for students to correct these errors. The adaptive system was used as an important assessment strategy, replacing traditional paper marking.

Teachers indicated a heavy reliance on the system's feedback function to assess learning. For instance, Teacher 1 said, *"For the questions that most students answered incorrectly, I demonstrated the steps to solve the problem in class."* Teacher 2 suggested that *"the student interface should display diagrams and pictures to illustrate the steps for solving problems so they can learn relevant problem-solving steps immediately."* Teacher 3 agreed and emphasised the pedagogical significance of diagrams and illustrations in aiding comprehension. He added, *"Science subjects involve many laws and theorems—In my teaching, Physics need diagrams and illustrations to transform an abstract concept into a concrete diagram to guide problem-solving methods."* Besides diagrams illustrating problem-solving methods, Teacher 3 recommended a personalised learning approach: *"The students can review the problem-solving steps according to their learning needs."* The system helped teachers manage students' learning diversity by providing individual questions according to their abilities. This accommodates their learning differences instead of giving the same questions to the whole class.

The teachers used the system not only as an assessment tool but also as a teaching aid, informing more effective teaching practices. They provided feedback on students' learning strategies to improve problem-solving abilities in mathematics based on student performance data from the platform. Teacher 1 gave such an example, saying, *"The data shows that Student B answered a lot of questions wrongly, and it is still concentrated in Lv1 with a lower level; I can suggest Student B watch the instructional videos online and do more targeted exercises to consolidate the basics. Likewise, suppose the data shows that Student A has answered many questions correctly, especially those at the more advanced Lv3. In that case, I can suggest that Student A go to the library to find some more advanced supplementary exercises to do."* This suggests teachers perceived the platform as a diagnostic tool, allowing them to understand students' learning situation earlier and provide targeted, high-quality feedback. These findings illustrate the platform's affordances of measuring and reporting students' learning results, as proposed by Yang & Xin [7], and the active construction of knowledge occurs [8].

During our investigation, the teachers highlighted two crucial improvements for the platform. First, they emphasised the need to enhance the search function for MC questions – the school has obtained the copyright of MC questions from various publishers, there is a pressing need to integrate a search engine into the platform. Integrating a search engine would allow teachers to effortlessly identify and group questions from diverse sources, generating unique practice materials for students at different levels. Second, teachers wished for manual question assignments to individual students based on their ability level. They suggested having the

autonomy to adjust class rules such as determining the number of correct answers needed for student promotion. However, this suggestion conflicts with data-driven adaptive learning's core principle. Despite this, it is understandable, as the adaptive learning system was in its early stages and lacked enough student data to train the system. This aligns with Timmis, Broadfoot, Sutherland, & Oldfield's [22] study, which suggests that AI can prompt educators to rethink assessment purposes. They may need to develop new assessment methods for meaningful learning in the digital age. Teachers wished for a "follow-up" function to control students' visual information, such as adding related videos or supplementary practices. According to Ng & Fergusson [31], the effectiveness of an adaptive learning platform hinges on teachers' ability to internalise new technological and content knowledge."

4.1.2 Gamification. Teachers found the platform allowed gamification of learning activities, arousing student interests. Teacher 1 reported that "Although the system isn't a game, the adaptive nature of the questions, which 'upgrade' and 'downgrade' in difficulty levels, simulates a video gaming experience. This dynamic adjustment mechanism can foster a sense of achievement, especially when students successfully tackle more challenging levels." Teacher 2 shared this experience and reported that "Students like playing games. Game-like practices are more interesting than simply doing exercise books." Teacher 2 also suggested incorporating an audio function for positive reinforcement: "I wonder if students who answer three questions correctly in a row can get applause. By adding auditory effects, students would be more engaged when using the system." Teacher 3 agreed and suggested that such features could appeal to his students. He said, "Our students, admittedly, often lack learning motivation. If elements of games can be wrapped in the system, their learning motivation will be enhanced. In this way, the system can encourage self-directed learning." From a pedagogical standpoint, Teacher 3 further suggested the idea of retrying questions in the system, akin to video games: "If a student answers a question incorrectly in the system, he can answer it again after the fact, [which is] similar to video games. No matter how difficult the level is, if the students try more, they will have a chance to clear the level, and after they clear it, they can challenge the more difficult level. In this way, students have the opportunity to win through self-study after being defeated, which can boost their sense of accomplishment." According to Tseng, Chai, Tan, and Park [35], teachers utilising TCK and TPCK pedagogies often encounter practical challenges when using technology platforms. These can be mitigated by incorporating their design knowledge and gamifying the platform to stimulate student motivation and learning. Koh and Chai [37] have identified gamification as an integral aspect of TPACK for the platform, underscoring the importance of effective lesson planning with technology to enhance student learning outcomes.

4.1.3 Self-Regulated Learning. Self-regulated learning was another pedagogy that teachers employed as they adopted the adaptive learning system. Teacher 1 said, "*I encouraged students to learn independently through the system to enhance their SPL ability. When students complete the exercise, they will immediately know whether their answers are correct or not and where they are wrong.*" The system could cater for students' learning differences; for a class with better grades, Teacher 2 reported, *"I arrange that students only need to answer two or three questions before they can be promoted to the next level of questions, while for a class with lower grades, they need to answer ten questions before they can get promoted to the next level."* To be promoted to the next level, the students must do more exercises to consolidate their foundation. The system not only supports teachers in taking care of students' learning needs through the teacher's fine-tuning but also motivates students to develop self-regulated learning behaviour.

Motivation plays a crucial role in self-regulated learning [69], and a person's intrinsic motivation to learn can be triggered by their interest in the subject [70]. Teacher 3 demonstrated that introducing a system could enhance students' interest in learning. They observed that if students in class A only tackled questions at a lower difficulty level (Lv1), they might struggle to maintain their motivation because the challenges would be insufficient. This finding aligns with prior research [11–13] that computer-based assessments for learning can provide timely feedback, keep students engaged, and enhance their ability to self-regulate their learning. Moreover, the study by Shute and Rahimi [20] showed that using assessment for learning strategies in the classroom can facilitate students' self-regulation.

4.2 Digital Leadership that Promotes Effective and Sustainable Use of Adaptive Learning Systems

In addressing the second research question, "How do school leaders overcome challenges to implementing this initiative?" the researchers concluded that digital leadership played a pivotal role. This tech-savvy school leader (the principal) consulted with teachers and reached a consensus to introduce an adaptive learning system to support the development of teaching and learning, which was documented in the school development plans. He initiated the adaptive learning approach as he engaged in a CoP gathering activity the researchers organised. Furthermore, the school leader demonstrated an understanding of knowledge management concepts and had previously used an information system to support daily school administration. This finding aligns with Chang's [41] study, indicating that school leader's attitudes and knowledge toward technology impact teaching effectiveness and teachers' ability to integrate technology into teaching. Unsurprisingly, school leader has mobilised resources to facilitate the successful implementation of this initiative. This conclusion echoes the findings of Dexter's research [44], which suggested that the leader created conditions conducive to the integrative pedagogical use of technology in schools.

The success of the initiative was largely due to the commitment of the school leader and teachers. To secure this commitment, the school leader addressed the needs of teachers, ensuring they were sufficiently motivated to participate in the project. However, many teachers were found to have misconceptions, overambitious goals, and unrealistic expectations regarding the development of AI systems and what AI can achieve. This situation is consistent with our previous research on AIED in similar school settings. Aligning project goals with the needs of teachers required significant communication between school leaders and teachers. Furthermore, due to

the involvement of data, additional communication was necessary to address security concerns related to the AI adaptive learning system.

The principal was open-minded and encouraged free communication; all topics could be discussed with fellow teachers. He understood the potential challenges of and resistance to this AI initiative. He presented a clear vision for teachers, understanding that informing them about the school's next steps would facilitate the implementation of new initiatives. He stated, "*It is expected that many challenges will be encountered when implementing new initiatives in our school. In promoting the system to other subject departments, it's wise to let colleagues understand our thoughts and next steps. Communication between teachers is crucial–not only because it builds trust, but it also familiarises each teacher with specific plans suited to their competency.*" The principal also encouraged individual teachers/subject teams to undertake R&D and fostered an environment tolerant of mistakes. These findings echo Garcia & Abrego's [40] study, which asserts that strong digital leadership involves familiarity with technology, using information retrieval, communicating with stakeholders, and managing resources.

The principal said, *"I have been presenting myself to our colleagues as a partner willing to walk alongside them; I understand that empathy is crucial as a leader. I consider that making mistakes is part of learning."* The principal has been implementing organisational learning in their school. He further explained, *"I always ensure my vice-principals are on the same page with me. Things run more smoothly with the vice-principal's adequate support."* In a follow-up interview with the school's vice principal, the researchers found that he was committed to pursuing the Learning with AI direction popularised by Wang & Cheng [71]. He clarified their perception of AI initiatives: *"The adaptive learning system is not merely a digitalisation or a mere replacement. Instead, it optimises and transforms existing teaching and learning practices."* He further explained, *"I persuaded different departments to try out this new adaptive system. To implement new initiatives, it's essential to understand the common difficulties teachers face."* He then shared the school records justifying the platform's implementation and added, *"If the new initiatives can address these 'pain points', there's a high likelihood of smooth implementation. For instance, the practice of students uploading their assignments to the system can significantly save teachers' time in conducting continuous assessments and can also help avoid missing assignments."* These findings align with Dexter's [44] studies; school leaders encourage technology adoption in teaching and learning explicitly through expressed preferences and mandates or implicitly through reward systems and incentives.

In summary, the interview findings with the school leaders support the assertion that they are digital leaders capable of effectively selecting and using ICTs for personal and organisational purposes, as claimed by Van Wart, Roman, Wang, & Liu [38]. They embody vision, professional development, infrastructure support, evaluation, and communication, as suggested by Chang [41].

5 CONCLUSION AND IMPLICATION

With the growing trend of harnessing AI to improve teaching and learning, this study delves into the pedagogical methods adopted with an AI-driven adaptive learning system and the leadership strategies essential for institutionalising this system. The pedagogical approach revolves around leveraging assessment results to enhance teaching and learning trajectories and incorporating gamification to bolster student motivation while fostering self-regulated learning. As for leadership strategies, they comprise effective communication with educators about AI's educational benefits and furnishing necessary resources to facilitate system use.

The findings of this study highlight the crucial role of supportive school leadership that encourages teachers to embrace adaptive learning platforms as a tool to advance student learning. Successful implementation of adaptive learning platforms necessitates a pedagogical shift from conventional teacher-centric approaches to more student-focused strategies, which can substantially improve student engagement and the quality of learning outcomes.

Additional recommendations include governmental resource allocation to aid schools in adaptive learning system institutionalisation and the support for universities to develop programmes for school leaders and teachers' professional development using such AI-powered systems.

The study, however, also bears the limitation of resource constraints that permitted only a single school selection. Consequently, there's a potential risk of overgeneralising the findings to all high schools. The fifth wave of Covid in Hong Kong prompted an abrupt halt to face-to-face teaching in January, along with an early onset of summer holidays as part of the government plan. This scenario directly impacted the project schedule. Prioritising school-wide Covid testing, safeguarding children's health and safety, and ensuring teaching and learning continuity became the primary focus for the participating school, often pushing research project concerns to the background. Nonetheless, the researcher consistently advocated for the potential of an AI adaptive learning system to enhance teaching and learning continuity amidst these challenging circumstances.

Further research is needed to examine student learning outcomes after using the adaptive learning system and to understand the extent to which teachers' professional judgement can interact with AI-generated assessments.

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