

Enhancing Middle School Students' Self-Efficacy through Game-Based Interaction in Blended Learning: Insights from Self-Determination Theory

Zhe Lu*, Mohd Shafie Rosli

School of Education, Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia

Email: shafierosli@utm.my

Corresponding Author Email: luzhe@graduate.utm.my

To Link this Article: <http://dx.doi.org/10.6007/IJARBS/v15-i5/25408> DOI:10.6007/IJARBS/v15-i5/25408

Published Date: 13 May 2025

Abstract

With the growing integration of information technology into education, blended learning has become a key model in secondary education reform. Yet maintaining student motivation and engagement—especially during self-directed learning phases—remains a major challenge. In this context, gamified interaction strategies that incorporate game elements such as points, levels, and rewards are increasingly seen as effective tools to enhance learning outcomes. This study explores how gamified teaching strategies affect middle school students' self-efficacy in blended learning environments. Drawing on Self-Determination Theory (SDT), which emphasizes the psychological needs for autonomy, competence, and relatedness, the research investigates how gamification can fulfill these needs and foster intrinsic motivation. Focusing on adolescents—who are highly responsive to interactive learning—this study uses questionnaire surveys and semi-structured interviews in several middle schools in Shenzhen's Nanshan District. The results show that gamification significantly improves students' interest, participation, and perceived competence, thereby enhancing self-efficacy. However, the effectiveness of gamification also depends on teachers' digital literacy and the design quality of gamified tools. This research contributes to theory by applying SDT in the context of gamified blended learning and offers practical insights for improving digital pedagogy. The findings are valuable for educators, curriculum designers, and education technology developers aiming to create more engaging and effective learning experiences.

Keywords: Self-Efficacy, Self-Determination Theory, Blended Learning, Interactive Experience

Introduction

Students' learning outcomes are closely related to their active participation in the learning process. In recent years, with the rapid development of educational technology, the

innovation of teaching methods and learning models has ushered in unprecedented opportunities. In particular, the widespread application of blended learning has brought revolutionary changes to the education system worldwide. The blended learning model combines online learning with traditional face-to-face teaching. Through flexible teaching arrangements and technical support, it can not only meet the needs of different learners, but also significantly improve learning effects while increasing interactivity and personalization. However, although this model has shown many advantages in practice, how to stimulate students' learning motivation, especially in the self-driven learning process, is still a key challenge in educational technology research.

With the continuous evolution of educational practice, traditional face-to-face teaching is gradually transforming to online and blended teaching. This trend has prompted the education community to continue to explore more innovative and adaptive teaching methods and strategies. As an effective model that integrates online and offline resources, blended learning has received increasing attention and is believed to help improve students' learning motivation and participation. However, in this technology-dominated environment, teachers and students still face the challenge of maintaining learning outcomes and motivation. Therefore, designing teaching strategies that can effectively stimulate students' intrinsic motivation has become an important topic in current educational research (Krouska et al., 2022).

Under this transformation trend, gamification teaching strategies have gradually become the focus of educators and researchers due to their advantages in improving students' learning motivation, participation and interactivity. Game-based learning (GBL) combines game mechanics with learning content, which can not only increase students' interest in learning content, but also improve their sense of self-efficacy, thereby promoting deep learning and academic achievement (Tsai et al., 2020). Among them, mobile game-based learning (MGBL), as a flexible teaching form, provides students with the opportunity to participate in learning anytime and anywhere with its high interactivity and convenience, greatly broadening the flexibility of learning scenarios and time.

Self-Determination Theory provides a theoretical framework for this study. The theory emphasizes that students' learning motivation stems from the autonomy, competence, and sense of connection gained during the learning process. Only when these basic psychological needs are met will students show a high degree of intrinsic motivation, thereby enhancing learning efficiency and persistence. Studies have shown that in a gamified learning environment, students' self-efficacy has a significant impact on their learning behavior (Al-Abyadh & Abdel Azeem, 2022). Therefore, this study focuses on how gamified interactive strategies can enhance middle school students' learning motivation and participation by improving their self-efficacy in a blended learning environment.

The main goal of this study is to explore the impact of gamification interaction strategies on middle school students' self-efficacy in a blended learning environment, and to analyze how to stimulate students' intrinsic motivation by satisfying their autonomy, competence, and sense of relationship, and ultimately improve their learning performance, combined with SDT. Specifically, this study will focus on how gamification learning can stimulate students' learning interest and self-efficacy through interactivity, feedback mechanisms, and personalized

features, and on this basis, propose effective teaching strategies and practical paths to further promote innovation in educational technology and teaching models.

Literature Review

Mobile Game-Based Learning (MGBL)

With the continuous advancement of technology, game-based learning (GBL) has become one of the most popular teaching strategies in the field of contemporary education. GBL aims to combine learning content with the appeal of games, and stimulate students' learning motivation and improve learning outcomes through the interactivity, feedback mechanism and challenge of games. Although the academic community has not yet reached a consensus on the definition of "game", most researchers agree that games have the following five core characteristics: first, they are rule-based and follow clear game logic; second, they have system responsiveness and can provide instant feedback based on player operations; third, they are challenging and often incorporate accidental factors; fourth, the game progress is cumulative, reflecting the player's past actions and performance; fifth, they have incentive mechanisms that can continuously attract player participation (Lomos et al., 2023).

For this reason, games are considered one of the most attractive and motivating activities, especially among children and adolescents. Games not only provide them with opportunities to solve complex problems, but also guide them to develop innovative thinking (Bang et al., 2023; Ilten-Gee & Hilliard, 2021). Games with educational purposes and learning-related content are generally believed to make the learning process more interesting, immersive, and effective (Tsai et al., 2020). In this context, GBL has been proven to have significant advantages in improving student motivation, stimulating cognitive interest, and promoting deep participation.

Specifically, Sun et al. (2023) further pointed out that GBL has five key characteristics: (1) emphasizing "learning by doing" rather than passively accepting knowledge; (2) providing individualized motivation and satisfaction; (3) adapting to diverse learning styles and skill levels; (4) enhancing the mastery and consolidation of specific skills; and (5) creating an interactive and decision-making learning environment. These characteristics provide strong support for the effective application of GBL in different educational stages and diverse educational environments.

After entering the 21st century, with the popularity of mobile devices such as smartphones and tablets, MGBL has rapidly developed into an emerging teaching form. MGBL realizes "ubiquitous" learning through mobile terminals, providing students with a more flexible and personalized learning path, enabling them to continuously accept learning tasks in fragmented time while obtaining instant feedback and opportunities for self-regulation (Sun et al., 2024). Chen et al. (2022) pointed out that in subjects such as mathematics, mobile game tutorials not only effectively improved students' academic performance, but also significantly enhanced their participation, self-efficacy and motivation levels.

In addition, Krouska et al. (2022) emphasized that the core advantage of MGBL lies in its positive role in promoting students' sense of competence. Students experience a sense of accomplishment by completing tasks, unlocking levels, and obtaining rewards in a gamified environment. This positive experience further enhances their enthusiasm and persistence in

learning. Studies have shown that game design with emotional support and high interactivity can effectively enhance students' learning experience and cognitive engagement. Therefore, when constructing a gamified learning environment based on intelligent technology, educators and designers should give priority to the dimensions of game features related to emotion, interaction, and motivation in order to achieve the dual goals of promoting learning goals and maintaining learning motivation (Sun et al., 2024).

Blended Learning

Blended learning, as a model that combines online learning and traditional face-to-face teaching, has become an important trend in education reform in recent years. The core concept of blended learning is to combine classroom learning with independent learning through information and communication technology (ICT), which can not only make up for the limitations of traditional classroom teaching, but also give full play to the flexibility and personalization advantages of online learning. Specifically, the blended learning model emphasizes the flexible delivery of teaching content, and usually 30% to 79% of the teaching content is presented online (Müller & Mildemberger, 2021). This teaching model enables students to better master knowledge in a personalized learning environment, while also being able to adjust their learning path according to their own progress and needs.

In blended learning, the conceptualization of digital classrooms further emphasizes the systematic integration of ICT into teaching activities. Although blended learning itself includes digital teaching media, in practice, several key issues must be effectively addressed: for example, at which stage of learning should digital content be included? How should the teaching model of the digital classroom be designed? (Kumar et al., 2021). These issues are related to whether blended learning can truly achieve its due flexibility and personalization goals. Therefore, when designing a blended learning environment, it is necessary to rely on existing empirical research results to ensure the effectiveness and operability of the strategy. Although blended learning has great potential in improving learning efficiency and flexibility, it also faces many challenges in its actual application. For example, over-reliance on technological tools may lead to insufficient innovation in teaching methods, and teachers' digital literacy and ability to adapt to new tools will also affect the effectiveness of blended learning (Bizami et al., 2023). In addition, how to design a blended learning environment that can both meet students' needs and give full play to the advantages of technology remains a key issue in educational research.

This study will combine the MGBL strategy to explore how to enhance students' learning motivation and participation through gamification interaction in a blended learning environment, especially the self-efficacy of middle school students in blended learning. By exploring the effectiveness of this strategy, it aims to provide a theoretical basis and practical guidance for gamification design in a blended learning environment.

Self-Determination Theory

Self-Determination Theory is the core theoretical framework of this study. SDT was proposed by Ryan and Deci (2017), emphasizing that individuals should obtain the satisfaction of three basic psychological needs: autonomy, competence, and sense of connection in the learning process. The theory points out that when these needs are fully met, students' intrinsic

motivation will be stimulated, which in turn drives them to participate more actively in learning and achieve in-depth learning.

In an educational setting, SDT distinguishes two main types of motivation: autonomous motivation and controlled motivation. Autonomous motivation usually stems from learners' intrinsic interests and growth needs, such as the desire for knowledge and skills, while controlled motivation relies more on external factors, such as rewards, evaluations, or social status (Guay, 2022). SDT believes that only when students' three major psychological needs are met, they are more likely to develop a high level of intrinsic motivation, which in turn leads to better learning outcomes.

Furthermore, SDT also proposes a continuum of motivation internalization. Xia et al. (2022) pointed out that teachers can effectively motivate students to participate in learning by meeting their psychological needs. When students' autonomy, sense of competence, and sense of relatedness are satisfied, their motivation will gradually transform from non-motivation to different stages of extrinsic motivation - including external regulation, internal regulation, identification regulation, and integration regulation - and finally transition to true intrinsic motivation. In this process, students increasingly internalize external goals as part of their own values, and then the meaning of the activity itself drives learning behavior. This intrinsic motivation can not only maintain students' personal growth and well-being, but also has the potential to improve learning outcomes. Therefore, if the teaching design can fully meet the three basic psychological needs of students, regardless of their initial motivation, it is more likely to be transformed into intrinsically driven learning motivation.

Self-determination theory also provides solid theoretical support for game-based learning. Chiu (2022) pointed out that gamification teaching strategies can effectively meet students' autonomy, competence and sense of relationship in the learning process through interactive mechanisms and feedback systems, thereby stimulating their intrinsic motivation and improving the initiative and sustainability of learning behavior. Therefore, when designing educational games, teaching elements that can respond to these three psychological needs should be consciously embedded to improve students' learning motivation and participation.

Self-Efficacy

In a broad sense, self-efficacy refers to an individual's belief in his or her ability to plan and execute the behaviors required to achieve a goal (Bandura, 1997). Bandura (2001) further pointed out that students' behavior is often a direct reflection of their judgment of their own abilities, and this self-efficacy belief not only affects their emotional response to tasks, but also affects their thinking patterns and coping behaviors. In an educational environment, self-efficacy is considered to be a core factor in regulating students' learning motivation and strategy selection. It determines the degree of persistence and initiative of students in solving problems when facing difficulties (Al- Abyadh & Abdel Azeem, 2022).

In recent years, as educational games have been increasingly introduced into classroom teaching, the role of self-efficacy in this new learning environment has gradually attracted attention. However, most existing studies still focus on the relationship between self-efficacy and academic performance at the macro level, and there is still a lack of systematic empirical research on how it specifically affects students' learning behavior and strategy choices in

games (Krouska et al., 2022). For example, Wang et al. (2022) found that students with higher self-efficacy are more likely to actively pay attention to key game navigation elements (such as dynamic icons) in educational games, showing stronger information integration ability and task focus. However, there is currently a lack of systematic theoretical construction and empirical support for how educational games in turn affect students' self-efficacy. Based on this, it is urgent to explore the dynamic interaction mechanism between self-efficacy and students' behavioral performance in educational games in order to reveal the adjustment path of personalized learning strategies and provide a theoretical basis for the design of gamified learning environments.

Educational games often provide students with continuous positive experiences through progressive challenges, immediate feedback, and visual achievement systems, thereby enhancing their sense of success and task control (Tannert & Gröschner, 2021). Studies have shown that students with good self-management skills are more likely to develop a positive sense of self-efficacy in this process, which is also affected by multiple factors such as family environment, school support system, and the quality of teacher-student interaction (Al-Abyadh & Abdel Azeem, 2022; Tannert & Gröschner, 2021). Therefore, when designing game-based learning situations, educators should not only consider the structure and fun of the game itself, but also pay attention to how it works with students' existing self-management abilities and emotional support systems, so as to effectively stimulate students' intrinsic motivation.

In summary, self-efficacy is not only an important variable for understanding the differences in students' behavior in gamified learning, but also a key factor in optimizing educational game design and personalized learning support. Future research should further combine quantitative tracking and qualitative analysis to explore its role in different stages of educational games, especially how to strengthen students' achievement expectations and learning confidence through game mechanisms, thereby improving overall learning outcomes.

In view of the above research gaps, this paper intends to focus on how middle school students can improve their self-efficacy through gamified interaction in a blended learning environment, and propose corresponding teaching strategies based on this. Based on the theoretical framework of SDT and self-efficacy theory, this study will systematically explore how middle school students can mobilize their self-efficacy in educational games, as well as the role of behavioral interaction and game feedback mechanisms in stimulating learning motivation and enhancing participation. This study will not only help deepen the understanding of students' behavioral patterns in gamified learning situations, but will also provide theoretical support and practical guidance for educational game design and teaching intervention for middle school students.

The study will use semi-structured interviews to explore the experiences and feelings of middle school students in a blended learning and gamified interactive environment, to understand how they perceive the improvement of their self-efficacy in this environment and the specific impact of this improvement on their learning motivation and behavior. Semi-structured interviews will help researchers obtain richer data from students' personal

experiences, thereby providing empirical evidence for the design and implementation of educational games.

Current Status and Problem Discovery of Mobile Game-Based Practice in Blended Learning

With the rapid advancement of digital education, Nanshan District Middle School in Shenzhen has gradually explored and implemented a variety of hybrid teaching models that integrate online and offline teaching in a "bring your own terminal" teaching environment, forming four typical digital teaching paths represented by flipped classrooms, mobile application software, smart platforms, and interdisciplinary project-based learning courses (Cao, 2024). In particular, in terms of maker-style teaching and gamification learning, a certain local practice foundation has been accumulated, initially showing the potential to improve student participation and learning interest.

The hybrid teaching model in Nanshan District mainly includes: (1) Flipped classroom teaching model: By combining online learning before class with offline interaction in class, students can learn independently and participate in class. (2) Maker and gamification learning model: Combining hands-on operation and game mechanism, students can be guided to master knowledge in depth in an interesting learning environment. (3) Personalized learning model: Use intelligent teaching platforms to analyze learning data and provide real-time feedback to meet students' personalized learning needs and promote differentiated teaching. (4) Interdisciplinary project-based learning: Through project-based learning, science, technology, engineering, art, and mathematics are integrated to stimulate students' innovative thinking and improve their comprehensive quality.

Although these practices have enhanced the digitization and interactivity of teaching to a certain extent, from the perspective of students, how to further stimulate their intrinsic motivation and enhance their sense of self-efficacy is still a core issue that needs to be broken through. For example, different types of interactive tools have different effects on students' autonomy and sense of achievement; gamification elements in some classes remain at the superficial level of fun and have not yet formed an intrinsic drive for continuous learning behavior.

In order to further understand the real experience and potential dilemmas of middle school students in Nanshan District in the current digital teaching practice, this study designed a semi-structured interview, focusing on students' subjective feelings and actual needs in terms of learning motivation, self-efficacy, teaching interaction, and overall feedback. The interviewees were mainly middle school students who had participated in the above-mentioned typical digital teaching model. The specific interview dimensions and core question design are shown in Table 1. The interview results revealed some key problems faced by students when using digital tools for learning. These problems not only reflect the shortcomings in existing teaching practices, but also provide valuable insights for further optimizing teaching models. Next, several major issues found in the interviews and their potential impacts will be discussed in detail.

Table 1

Dimensions and examples of semi-structured interview question design

Interview Dimensions	Specific problem examples
Learning experience and participation	What gamified learning tools have you used in your classroom? What impact did these gamification elements have on your learning experience? Does gamified learning increase your participation? Why? Does blended learning increase your participation? Why?
Gamified cognition	Is gamified learning more attractive than traditional methods? What designs make you more willing to participate? Do you prefer gamified learning with elements such as rewards, points, and leaderboards? What is the appeal of these designs to you?
Learning motivation and self-efficacy	Do you think that learning motivation has changed after using gamification learning? If so, in what specific aspects? Did the gamification elements help you gain more control over your learning progress and content? Did your sense of self-efficacy improve?
Teaching interaction evaluation	Does gamification enhance your interaction with teachers and classmates in class? Which game designs or interactive forms make you feel more engaged? Do you feel that you can get immediate feedback during the gamified learning process? Does this feedback help you learn better?
Overall feedback and suggestions	What do you think is the most effective part of gamification learning? What aspects do you think can be further improved? Would you recommend gamification learning to other students? Why?

Gamification Design Lacks Persistence of Interest

In interviews with middle school students in Nanshan District, Shenzhen, China, students generally reflected that gamification design could attract their attention at first, but their interest in learning gradually declined over time. Most students said that when they first entered the gamification learning mode, they felt fresh and excited, and the interactivity and reward mechanism of the game brought them a short-term pleasant experience. However, as the learning tasks were repeated, many students pointed out that the game tasks were not innovative enough and the content was too monotonous, which led to their waning interest in the game. Some students mentioned that there was a lack of meaningful challenges and changes, and the difficulty of the tasks did not increase effectively, which could not motivate them to continue learning. More importantly, there was no direct connection between the game's reward mechanism and students' learning achievements. Students could not see their improvement in knowledge mastery from the game, which made them feel that gamification learning lacked substantial learning returns and thus lost the motivation to participate.

The Integration of Gamification Learning and Subject Content is Low

Another significant problem is that the gamification design is not closely integrated with the subject content, resulting in students not getting the expected improvement in subject knowledge during the game. Many students said that although the tasks in the game are interesting, they do not form an effective connection with the knowledge they have learned in class. For example, when students participate in math tasks, although the game provides elements of numerical calculations and logical reasoning, students fail to deeply understand the mathematical principles in the game, but only complete the tasks through repeated

operations. Language learning games are similar. Students can get some language input in the game, but these inputs are usually lacking in practicality and challenge, and cannot help students consolidate and expand the language knowledge they have learned in class. The content of the game focuses more on entertainment rather than the imparting of knowledge. Therefore, students feel that although the game is interesting, it cannot help them effectively improve their subject ability.

Insufficient Support for Personalized Learning

Middle school students generally reflect that the learning content of the platform lacks personalized support, and the platform fails to provide adaptive learning resources based on their learning progress, ability differences and interest preferences. Many students mentioned that they often encounter tasks that are too difficult or too easy in the game, resulting in unsatisfactory learning results. For example, some students are good at mathematics, but the tasks they encounter on the platform are mostly basic content, which fails to stimulate their thinking potential; while other students feel frustrated and confused because the tasks are too difficult. In addition, the platform does not make appropriate adjustments based on students' learning records or behaviors, lacks a real-time feedback mechanism, and students fail to receive timely help or guidance when facing challenges. Students hope that the platform can adjust the difficulty of tasks according to their learning trajectory and provide more personalized challenges to help them improve their learning efficiency.

Lack of Interactivity and Social Elements

Although gamification design can stimulate students' individual learning interests, its lack of interactivity and social elements limits students' cooperation and collective learning experience. In the interview, many students said that although the game tasks gave them a sense of accomplishment when they completed the challenge, most game tasks were limited to individual completion and lacked opportunities for teamwork. Students believe that if gamification learning can incorporate more social elements and teamwork tasks, it will help enhance their learning motivation and sense of participation. Many students hope to interact with their peers in real time in the game, share learning experiences and even collaborate with each other to solve problems in the process of teamwork, and improve each other's social skills and team spirit. In addition, there are also deficiencies in teacher-student interaction. Many students reported that they could not get timely feedback from teachers after completing game tasks, and the learning process lacked necessary guidance and suggestions, resulting in low learning efficiency.

Poor Technical Adaptability

The technical adaptability of the platform is also a prominent issue mentioned in the interview, especially the poor adaptability to low-end devices. Students said that although their device configuration is not low, it is still common for games to load slowly and operate unsmoothly when using the platform. Especially when using mobile devices, the platform's response speed is slow, and the jamming during task loading seriously affects students' experience. In addition, some students mentioned that the platform's interface design is relatively complex, not intuitive enough, and the operation is cumbersome, and some functions have poor compatibility on different devices, especially the cross-platform operation experience. Students hope that the platform can provide more stable and smooth

technical support to ensure smooth learning on different devices and operating environments.

Optimization Strategies to Improve the Effectiveness of Mobile Game-Based Learning in Middle School Education

Dynamically Upgraded Gamification Design

In order to address the problem of insufficient persistence of interest in gamification design, a dynamic upgrade design strategy can be considered to gradually increase the difficulty and challenge of game tasks, and continuously update the content as students progress in their learning. The platform should dynamically adjust the content and form of tasks based on students' feedback and participation, so that students have new challenges and goals at each stage of learning. By continuously increasing the complexity of tasks, students can not only feel the sense of accomplishment brought by progress, but also maintain freshness in the ever-changing tasks. In addition, the platform can set up a personalized task recommendation system to push the most suitable learning content according to students' interests and learning progress, avoid the monotony of tasks, and make the learning content richer and more interesting. Dynamic updates and personalized recommendations will help the platform maintain students' long-term participation and learning motivation.

Strengthen the Deep Integration of Subject Knowledge

In order to solve the problem of low integration between gamified learning and subject content, the platform should design more content that deeply integrates subject knowledge with game tasks, so that students can effectively consolidate and expand the knowledge learned in class in the game. The platform can introduce a task-driven learning model, allowing students to learn subject knowledge through practical problem solving in the game. For example, math games can design complex mathematical modeling tasks, requiring students to use mathematical principles to solve problems based on actual situations; language games can allow students to improve their language skills through situational dialogues and role-playing. In order to further enhance the depth of subject content, the platform can also stimulate students' desire to explore subject knowledge by designing challenges and competitions, prompting students to actively learn and apply what they have learned.

Personalized Learning Support and Feedback Mechanism

In order to enhance personalized learning support, the platform can use artificial intelligence algorithms and big data analysis technology to provide each student with tailored learning content and suggestions based on their learning progress, ability differences, and behavioral data. For example, the platform can set personalized learning goals for students and adjust the difficulty and challenge of tasks in a timely manner according to their learning situation. In addition, the platform should provide real-time learning feedback and guidance to help students understand their strengths and weaknesses in learning and give targeted improvement suggestions. For example, when students encounter difficulties in a certain knowledge point, the platform can recommend relevant review materials or exercises to help students overcome learning obstacles in a targeted manner and ensure that students make continuous progress in the gamified learning process.

Increase Interactive and Cooperative Tasks

In order to solve the problem of insufficient interactivity, the platform should add more cooperative tasks and social elements. For example, group cooperation tasks can be designed so that students need to work together with classmates to complete the tasks and solve problems through the wisdom of the team. This can not only enhance students' social interaction, but also promote the improvement of teamwork and communication skills. The platform can provide interactive modes such as multiplayer real-time battles and teamwork, allowing students to compete or cooperate with their peers during the game, increasing the interactivity and fun of the game. At the same time, the platform should strengthen the interaction between teachers and students, and design functions for teachers to give real-time feedback to ensure that students can get timely guidance during the learning process.

Optimize the Platform's Technical Performance and Interface Design

In order to solve the problem of poor technical adaptability, the platform should optimize the technical architecture to ensure that the platform can run smoothly on various devices and network environments. First, the platform should enhance support for low-end devices to ensure a smooth operating experience on different devices. Secondly, the platform should simplify the operating interface to make it more intuitive and easy to use, reduce unnecessary operating steps, and allow students to easily enter the learning state. In addition, the platform should regularly update and optimize technology, fix existing technical loopholes, and ensure that students will not be troubled by technical problems during use. Through the implementation of these strategies, the quality and effect of gamification learning can be effectively improved, students' interest and participation in learning can be enhanced, and the in-depth mastery of subject knowledge can be further promoted.

Conclusion

This paper studies the current status of digital application of education for middle school students in Nanshan District, Shenzhen, China, and combines semi-structured interviews to deeply explore the real experience and potential dilemmas of students in digital teaching practice. The study found that although Nanshan District has gradually introduced digital and interactive tools in teaching, which has improved students' learning participation, there are still many problems, especially in stimulating students' intrinsic motivation, enhancing self-efficacy, and optimizing interactive methods. First, the study reveals the problems in current digital teaching practice, mainly including the lack of students' motivation for autonomous learning, the limitations of the use of interactive tools, and the singleness of teaching methods. These problems have caused some students to be unable to obtain continuous learning motivation in class, which in turn affects their learning effect and the improvement of their self-efficacy. To solve these problems, this paper proposes targeted optimization strategies, focusing on innovating interactive methods, enhancing students' motivation for autonomous learning, and enhancing the functionality and fun of educational digital tools. Specific strategies include: introducing diversified interactive forms, such as group cooperative learning and contextualized task design, strengthening the depth and breadth of gamification elements, combining personalized learning paths and feedback mechanisms, and making full use of Generative Artificial Intelligence and data analysis to provide personalized support. In addition, it is recommended that schools strengthen the cultivation of teachers' digital teaching ability and improve their ability to flexibly use technological tools in teaching. Overall, the strategies proposed in this study can not only help improve the effect

of digital education application for middle school students in Nanshan District, but also provide valuable experience and reference for other regions in promoting the digital transformation of education.

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