Research on Blended Learning in Middle School Mathematics Classes

Yuxi Wang *

School of Economics and Commerce, Guangdong University of Technology, Guangzhou, Guangdong, 510520, China

* Corresponding author: 3217008465@mail2.gdut.edu.cn

Abstract. Blended learning is gaining importance in the field of education as a result of the quick advancement of science and technology. There is a rising understanding of the necessity of integrating technology and digital resources into traditional classroom settings as educational systems continue to evolve. Combining in-person instruction with online learning activities is known as blended learning which offers a promising approach to enhance student engagement and improve learning outcomes in mathematics education. The objective of this research is to explore the impact of blended learning on middle school mathematics education, further understand its significance in improving student learning outcomes and interest, reveal the current status of blended learning in middle school mathematics classes, and provide some suggestions. The research finds that students will face the challenge of self-regulation in blended learning, students' personalized learning should be paid attention to, students' affective factors are also important, and students' negative learning attitude will lead to lower scores. In addition, the individual guidance from teachers is insufficient and the effective evaluation needs to be improved. Some teachers are even intimidated by new technology, which leads to the reduction of their teaching innovation. To overcome these challenges, student engagement should be increased, teacher planning should be optimized and a support system should be built. Through the research on blended learning, hopefully, this paper can provide support for improving mathematics education.

Keywords: Blended learning, middle school education, mathematics education.

1. Introduction

An educational strategy called blended learning mixes in-person instruction with online learning. A flexible and individualized learning environment is made possible via blended learning, where students can access digital resources, collaborate with peers, and receive individualized instruction, both in the classroom and outside of it. With the integration of technology, blended learning in middle school mathematics classes can provide students with a more dynamic and interactive learning environment. By leveraging online tools and resources, teachers can create engaging activities, simulations, and games that promote active participation and a deeper understanding of mathematical concepts. Blended learning also offers opportunities for students to learn at their own pace and revisit concepts that they may find challenging. Overall, using blended learning in math classes for middle schoolers has the potential to improve the student's motivation, engagement, and mathematical achievement.

With the rapid development and popularization of information technology, blended learning has attracted increasing attention. The consequences of implementing blended learning in mathematics classes have been studied in the past. According to some of this research, blended learning can increase students' comprehension and use of mathematical concepts, as well as enhance their motivation and self-directed learning. Not only can blended learning make full use of effective teaching resources to make up for the shortage of class hours and the limitation of learning time and space, but the fusion of audio, video, and image can further satisfy the learning interest of students in the new era, and has an obvious effect on stimulating students' desire for knowledge [1]. Furthermore, an empirical study found that only by the appropriate intervention of the instructor, strengthening the learning support in the aspects of group members, subject selection, activity process, and outcome evaluation, and promoting the controllable degree of cognitive conflict within the cooperative group,

can the development of knowledge construction be ensured to the advanced stage of collaborative construction and evaluation and reflection, so that cooperative learning can move towards higher-order thinking such as innovation and critical thinking [2]. Especially in middle school mathematics education, the research found that blended learning can promote students' learning effect, improve students' problem-solving ability, and have a positive impact on mathematical thinking ability. For instance, in geometry teaching, blended learning allows students to experience the process of concept formation, construct abstract concepts from their own experience, and explore their related properties with concrete models [3]. Researching the implementation of blended learning strategies in secondary school mathematics classes holds significant importance in enhancing teaching methodologies and improving students' academic achievements.

At present, most of the research on blended learning mainly focuses on higher education, and there are relatively few researches on blended learning in the field of middle school mathematics education. Secondly, there is still a lack of systematic exploration of the influence of blended learning on middle school mathematics learning outcomes and learning motivation. In addition, teachers' attitudes towards blended learning and the specific application of instructional design and guidance also need further research. Therefore, this study aims to further explore the effectiveness of blended learning in middle school mathematics classes to provide more effective educational methods and strategies for middle school mathematics teaching. Traditional face-to-face teaching mode has been unable to meet the diversified learning needs of students, but blended learning can provide a more abundant and flexible learning mode by combining traditional teaching in the classroom and network technology. Therefore, the research on the application of blended learning in middle school mathematics classes has important guiding significance for educational practice, which is helpful to optimize teaching methods and improve student's learning effectiveness and discipline accomplishment. The objects of study include the teaching methods that combine online and offline teaching resources and activities in blended learning, where online learning can include online courses, video explanations, interactive textbooks, and learning platforms, while offline learning refers to traditional face-to-face teaching activities. This study will focus on how to make full use of the advantages of blended learning to optimize middle school mathematics courses, improve students' understanding and mastery of mathematics knowledge, and promote their learning motivation and academic performance.

2. The Impact of Blended Learning on Mathematics Classes from Students' Perspectives

2.1. Self-regulation Challenge in Blended Learning

In blended learning, students' self-regulation ability plays an important role. They need to learn to manage their learning time so that they can effectively engage and master knowledge in the face of both online learning and face-to-face teaching. In addition, students need to learn to set learning objectives and develop a corresponding learning plan to ensure that they can take full advantage of the various resources and opportunities in the blended learning mode. Self-regulation also involves the management of students' attention and the maintenance of their learning motivation. They need to learn to pay attention, resist temptation, and maintain interest and motivation in math learning. By providing self-regulation skill development and support, blended learning can help students develop better learning strategies and self-directed learning abilities.

Self-regulation is the spontaneous, systematic goal-oriented thoughts, attitudes, and behaviors of learners. To gain a comprehensive understanding of online learning, it is imperative to consider learners' self-regulation. Particularly in blended learning settings, self-regulation can effectively improve learning engagement. Students with high levels of self-regulation possess exceptional abilities in time management, learning process control, and timely adjustment of learning strategies. As a result, they can maintain focus and concentrate on their studies, whether in online or in-person classes. By actively participating in hybrid synchronous courses, students not only enhance their engagement but also exhibit higher levels of learning persistence, which correlates positively with

their self-regulation [4]. This highlights the significance of self-regulation in blended learning and its advantageous impact on fostering a sustained commitment to learning.

In addition, research has indicated that students' academic success and timely completion of courses are closely linked to their ability to employ effective self-regulation learning strategies. Conversely, those who lack these strategies may struggle to achieve success in online learning environments [5]. These self-regulation learning strategies encompass four key areas: cognitive strategies, metacognitive strategies, motivational strategies, and management strategies. However, despite the potential benefits of blended learning, it is often observed that the learning environments fail to adequately support students' needs, particularly in terms of developing and enhancing their self-regulation skills. The challenge of self-regulation presents a significant obstacle for many students. Given the flexibility and autonomy afforded by blended learning, students may allocate insufficient time towards essential study tasks, like reviewing materials and organizing their learning activities in advance of deadlines. As a result, learners often prioritize other activities, thus limiting the time they spend on online learning activities [6]. Educational institutions must address this issue and provide students with appropriate guidance and support in developing effective self-regulatory behaviors. By doing so, students can optimize their online learning experience and improve their overall academic performance. Furthermore, fostering self-regulation skills will equip students with essential lifelong learning capabilities that extend beyond the realm of education, empowering them to excel in various facets of their lives.

2.2. Blended Learning Personalizes Students' Learning

In a blended learning environment, students can develop learning paths and goals based on their interests, abilities, and learning styles. Blended learning enables students to acquire mathematical knowledge and skills at their own pace and in their way. In addition, it fosters students' self-directed learning and self-assessment skills, laying the foundation for their academic development and personal growth. Therefore, in exploring how blended learning personalizes students' learning experiences, it is needed to have a deep understanding of the importance of personalized learning and how to optimize the effects of personalized learning.

The importance and benefits of personalized learning in middle school mathematics blended learning cannot be ignored. By setting personal learning goals and expectations, students can gain a clearer understanding of what they hope to achieve in their mathematics learning. This helps to motivate students and gives them a clearer sense of their progress. Individual learning goals and expectations can also help students better plan and organize their learning programs. By identifying the knowledge and skills that they want to master in their mathematics courses, students can arrange their study time rationally and choose the learning resources that are suitable for them to support their math learning. In this way, individual learning ability can be improved and students can use the various learning tools and platforms in the blended learning environment more effectively. In addition, personalized learning enables students to develop self-directed learning and self-assessment. In a blended learning environment, students need to learn to think independently, solve problems by themselves, and actively seek resources and support for learning. Through self-directed learning and self-assessment, students can monitor their learning progress and make adjustments and improvements as needed. This ability to learn independently and awareness of self-assessment is important not only for mathematics learning but also for students' lifelong learning. Through the practice of personalized learning, students will be able to better utilize the various resources in the blended learning environment to achieve their learning goals and achieve better learning outcomes.

However, in the face of so many choices, too much freedom to determine the personalized paths of learning including location, time, space, and other elements can also lead to cognitive overload. Being given too many choices when studying a topic with which students are unfamiliar will increase their cognitive load. For learners who need to focus on skills and the content itself, where the learner is dealing with unorganized or novel information, guided choice helps prevent cognitive overload rather than adding cognitive load by deciding when and where to control by themselves [7]. If students

can make proper choices, they will benefit from efficiency, engagement, and unparalleled meaning creation. Instructional designers and educators should determine the right time, the right amount, and the right circumstances to enable students to control the changing environment and continue to develop both face-to-face and online.

2.3. The Impact of Blended Learning on Students' Learning Attitudes

Mathematics plays an important role in modern society and has a profound impact on daily life. No matter whether it is scientific research, engineering design, finance, medicine, or other fields, it is inseparable from the application of mathematics. Mathematics education holds great significance, not only in terms of individual growth but also in its pivotal contribution to the advancement and prosperity of society. During the teaching process, nevertheless, there always are students who are resistant to mathematics. They presuppose that mathematics is a difficult subject to learn and think that they cannot learn mathematics well. Research shows that, in general, many students have negative attitudes toward the subject of math and their ability to succeed in math courses [8]. Attitudes, or the tendency to react positively or negatively to particular phenomena, situations, institutions, or people, are determinants of human behavior and are predictors of success. When students think that math is inherently difficult and worry about whether they can succeed in math, it detrimentally impacts their disposition towards math. Consequently, students tend to experience a decline in confidence levels [9]. In turn, negative attitudes toward math often translate into poor math performance.

In a traditional classroom, some students may feel dull about math and lack an understanding of the practical application and meaning of math content. In addition, they may also face academic stress and frustration, leading to an aversion to mathematics. However, when it comes to blended learning, middle school students may have different attitudes. They are used to teachers imparting knowledge in class, and in blended learning, they need to take the initiative to use computers and other devices to complete homework and learning activities, which may cause their resistance. They may hold negative views or be uncomfortable with the use of technology-assisted learning, feel unable to engage in face-to-face communication and discussion with classmates and teachers as they would in a traditional classroom and worry about the lack of social interaction and communication opportunities in blended learning. Therefore, students require a certain duration to acclimate themselves to the novel educational approaches and surroundings.

By gaining a profound insight into the present attitudes and preferences of adolescents in secondary education, it is possible to better design and promote blended learning programs to meet their needs and improve their math learning outcomes. Blended learning emphasizes the role of students in controlling their learning experience, including factors such as time, place, path, and speed. Frazier, in his research, emphasized the significance of self-paced and asynchronous learning events in blended learning, noting that students find these elements particularly valuable [9]. Moreover, the findings of the study indicate that blended learning can effectively be utilized as an instructional strategy for teaching high school geometry. Notably, the research demonstrated that all students showed growth in their learning outcomes, with an impressive 81% of students successfully passing the posttest. This highlights the potential of blended learning to achieve positive educational outcomes.

3. The Impact of Blended Learning on Mathematics Classes from Teachers' Perspectives

3.1. Teachers' Individual Guidance in Blended Learning

As teachers, understanding the individual needs and learning styles of students is crucial for effective teaching. In blended learning, the use of technology allows for personalized instruction and individual guidance. Through online platforms and tools, teachers can deliver tailored content and

assignments that suit each student's level and pace. Additionally, teachers can provide one-on-one support and feedback to students, helping them overcome challenges and deepen their understanding of mathematical concepts. This individualized approach enhances student engagement and promotes a more meaningful learning experience.

Individual guidance in blended learning is of great importance to teachers in middle school mathematics classes. In blended learning, students learn independently through online learning platforms, but individual guidance from teachers is still crucial. First, individual instruction can meet students' different learning needs and levels, helping them overcome difficulties, understand concepts, and solve problems. Second, individual instruction helps build interaction and trust between teachers and students and promotes students' active participation and motivation to learn.

However, there are some deficiencies in the practice of individual guidance. Time and human resource constraints may prevent teachers from fully conducting individual instruction, and some students may feel stressed or uncomfortable during individual instruction. Therefore, to effectively implement individual instruction, teachers need to arrange their time reasonably and pay attention to students' psychological state to ensure the quality and effect of individual instruction.

3.2. The Challenges of Technology Application and Teaching Innovation in Blended Learning

One significant challenge that teachers encounter in the online aspect of blended learning is the need for enhanced technology literacy and competence. Integrating technology into mathematics classes opens up opportunities for innovative teaching strategies and delivery methods. In blended learning, teachers can make use of various digital resources and interactive tools to enhance instruction and engage students in active learning. For example, virtual manipulatives and simulations can be used to visualize abstract mathematical concepts, making them more accessible and interesting for students. Teachers can also incorporate multimedia elements, such as educational videos and online discussions, to promote deeper understanding and critical thinking. By embracing new technologies, teachers can create dynamic and interactive learning environments that foster creativity, collaboration, and problem-solving skills.

However, certain educators may face challenges when it comes to adopting new technologies for blended learning and utilizing a learning management system effectively. These challenges primarily stem from a lack of confidence, limited time, and reluctance to engage in the learning process associated with these advancements [10]. In addition, some teachers are technically illiterate and technologically anxious to resist teaching with new technologies [6]. Creating and managing courses is quite difficult for them, and they are reluctant to learn and teach using new technologies, preferring to use traditional teaching methods. In hybrid asynchronous learning environments, they focus too much on remote students and waste a lot of class time on solving technical problems.

Producing high-quality online videos has always been one of the biggest challenges for teachers, especially in blended learning. Long et al. reported that educators implementing blended learning methods dedicate a considerable amount of time and energy to the development of online instructional materials, including the creation of online videos [11]. The online aspect of blended learning poses significant technical obstacles for educators as well. Teachers find it challenging to operate the system seamlessly and be proficient in using instructional technology. Teachers will worry about how to eliminate technical problems, how to reduce the time to solve technical problems, how to better design online courses, and how to manage time [6]. Given the significant role technology plays and students' innate curiosity and fascination with it, it is imperative for teachers to receive adequate technical support and instructional guidance from their educational institutions.

3.3. The Lacking of Effective Evaluation in Blended Learning

Evaluating student learning and progress is a crucial aspect of teaching. In blended learning, teachers can utilize a range of assessment methods to effectively evaluate students' mathematical understanding and skills. Traditional methods, such as quizzes and tests, can be combined with online assessments and interactive activities to provide comprehensive and timely feedback to students. The

use of educational platforms and learning management systems allows teachers to track student performance, identify areas of improvement, and differentiate instruction accordingly. Additionally, formative assessments, such as online discussions and group projects, enable teachers to assess not only students' knowledge but also their ability to apply mathematical concepts in real-world contexts. By implementing various evaluation strategies, teachers would like to ensure that students are achieving the desired learning outcomes and make informed decisions for instructional planning.

Effective assessment is key to ensuring student learning outcomes in blended learning. Teachers need assessments to understand the knowledge and skills students have acquired so that they can provide further guidance and support based on their performance. Assessment tools can not only help teachers understand students' learning progress but also provide students with timely feedback and guidance to promote their learning motivation and self-learning ability.

However, there are some shortcomings in assessment in blended learning. First, technology-based assessment tools may not fully and accurately assess student learning outcomes. For example, for a math course, there are many different ways to solve certain problems, but an online test sometimes only assesses a student's ability to solve a problem using a specific method. In addition, some assessment tools focus more on students' numeracy skills and neglect the development of their thought processes and problem-solving skills. In addition, the assessment of student performance and engagement in the classroom can be limited due to the lack of real-time face-to-face communication opportunities in online learning.

4. Suggestions for Improving Blended Learning in mathematics classes

4.1. Increase Student Engagement in Blended Learning

Based on previous research findings, student engagement encompasses three distinct dimensions that are closely intertwined: behavioral engagement, emotional engagement, and cognitive engagement [4]. Specifically, behavioral engagement refers to participating in activities in blended learning, following rules or standards, and focusing on self-learning. Emotional engagement encompasses the cultivation of students' affirmative sentiments towards various aspects such as learning activities, classmates, and instructors. Cognitive engagement denotes the mental exertion required to acquire intricate knowledge and expertise through a blended and simultaneous learning experience.

To improve blended learning in math classes, student engagement needs to be focused. Blended learning offers a variety of flexible learning styles, but the active participation of students is key. First, teachers can teach students some self-management strategies which include cognitive strategies, metacognitive strategies, motivational strategies, and management strategies, such as elaboration, planning, self-efficacy, and so on, to help students successfully develop their self-direct learning abilities in blended learning. Secondly, when students learn difficult and unfamiliar materials, teachers should provide some guided choices to reduce students’ cognitive load. Furthermore, teachers can adopt interactive learning activities to encourage students to actively participate in discussion and problem-solving. Stimulate students' interest and engagement in math subjects through online discussions, group work, and project assignments. In addition, the use of technology tools and online resources to support the learning process, such as online exercises, real-time feedback, and personalized learning recommendations, increases student engagement and motivation in blended learning. Teachers can incorporate various interactive online activities, such as virtual simulations, gamified exercises, and collaborative projects, to capture students' interest and encourage active participation in the learning process. By creating a dynamic and interactive online environment, students are more likely to stay motivated and develop a deeper understanding of mathematical concepts.

4.2. Optimize Instructional Design in Blended Learning

To further enhance the effectiveness of blended learning in mathematics classes, it is crucial to optimize instructional design. This involves careful consideration of the curriculum, instructional strategies, and technological tools that can best support student learning.

In terms of curriculum planning, teachers should align the content with the specific learning objectives and outcomes they intend to achieve. They need to identify the key topics and skills that students should focus on, ensuring a coherent and logical progression throughout the course. By mapping out a clear structure, teachers can better guide the student's learning journey and ensure that important concepts are covered in the appropriate sequence. Teachers should carefully design and organize online resources, including instructional videos, interactive tutorials, and practice materials, to align with the curriculum objectives. Adequate preparation and sequencing of online and offline activities are necessary to ensure a smooth transition between different learning modalities.

Instructional strategies play a vital role in keeping students engaged and motivated in blended learning environments. Educators are encouraged to explore a diverse array of teaching methodologies that cater to unique learning styles and preferences which may include interactive videos, virtual manipulatives, gamified activities, and collaborative projects. By offering diverse learning experiences, teachers can address the individual needs of their students and foster a deeper understanding of mathematical concepts. Additionally, teachers can monitor students' progress through online platforms, provide timely feedback, and tailor their instruction accordingly to meet individual learning needs. Moreover, with online platforms, teachers can effectively evaluate students' learning and provide individual guidance.

In addition to curriculum and instruction, teachers need to consider the technological tools and platforms that will facilitate effective blended learning experiences. They should explore and select educational software, apps, and online resources that are user-friendly and aligned with the curriculum. Proper training and support should be provided to both teachers and students to ensure they can effectively navigate and utilize these tools.

By optimizing instructional design in blended learning, educators can create more engaging, well-structured, and student-centered mathematics classes.

4.3. Build a Support System for Blended Learning

Building a support system for blended learning is crucial. Schools should invest in the necessary technological infrastructure, such as reliable internet access, digital devices, and educational software, to support blended learning initiatives. Teachers should receive training and professional development opportunities to enhance their pedagogical knowledge and technical skills related to blended learning. Moreover, fostering a positive class culture that promotes collaboration, critical thinking, and self-directed learning is vital for creating an effective blended learning environment in middle school mathematics classes.

Schools should provide access to necessary technological resources. Schools should ensure that all students have access to the required devices and internet connectivity for effective participation in blended learning. This may involve providing loaner devices or internet hotspot solutions for students who do not have access at home.

Schools should create a supportive online platform. Schools should utilize user-friendly learning management systems or platforms that facilitate seamless communication, collaboration, and interaction between students and teachers. These platforms should have features that allow for easy submission of assignments, discussion forums, and real-time feedback.

Schools should establish clear guidelines and expectations. Schools should communicate the goals, guidelines, and expectations related to blended learning to both students and parents. This will help create a structured learning environment and avoid confusion or misunderstandings.

Schools should foster a positive learning culture. Schools should encourage active participation, critical thinking, and peer collaboration in both virtual and physical classroom settings. Foster a

mindset that values growth and enhance avenues for students to contemplate their accomplishments and establish targets for self-improvement.

Schools should support teachers with professional development. Schools should provide ongoing training and support for teachers to help them effectively incorporate technology into their teaching practices and to design engaging and interactive blended learning activities. This will ensure that teachers can navigate and utilize the available tools and resources to enhance student learning.

5. Conclusion

According to the student's point of view, blended learning is an effective teaching method in mathematics classes. For students, self-regulation is an important aspect of blended learning, which has a close relation to their abilities to manage their time, monitor their progress, and develop study plans. At the same time, students get an individual learning experience through blended learning, and they can learn according to their learning style and pace. However, they also need to overcome the self-regulation challenge and change their negative attitudes towards learning mathematics.

From the teacher's perspective, blended learning provides opportunities for individual tutoring, where teachers can better focus on the learning needs of students and personalize instruction to each student. In addition, technological innovation and the application of teaching methods can help teachers to improve the teaching effect. Effective evaluation is also a key element in blended learning, helping teachers to understand students' progress and quickly adjust teaching methods.

As for the suggestions to improve blended learning in mathematics class, firstly, students' participation in blended learning should be increased. Teachers can design interactive and fun learning activities that encourage students to participate actively. Secondly, teachers should optimize the instructional design of blended learning to provide students with clear learning goals and guidance. Finally, a support system for blended learning should be established, including a good Internet connection, suitable learning software, equipment, an effective evaluation platform, and training for both teachers and students.

This research focuses on the practice of blended learning in middle school mathematics classes, and the relevant suggestions are put forward from the perspective of students and teachers, which is helpful to improve the educational practice and improve the learning effect of students. Future research could further explore the application of blended learning in other disciplines or fields and compare the effects of different educational models.

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