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PAPER

Study on the Impact of Gamified Teaching Using Mobile Technology on College Students' Learning Engagement

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ABSTRACT

Mobile technology has become an indispensable resource in people's lives, and educational software applications are closely related to day-to-day life. These applications provide an effective basis for implementing interactive teaching and allow teachers and students to quickly exchange information through mobile devices. Compared with teachers, students are tolerant and open about mobile technology. To meet the learning needs of students, adopting different teaching methods to improve learners' learning outcomes is the focus of mobile learning. Therefore, gamified teaching supported by various information technologies such as computers, multimedia, and mobile technology has received widespread attention. In this study, 124 undergraduate students majoring in Civil Engineering from Harbin University of Science and Technology, Heilongjiang Province, were randomly assigned to one experimental group (with gamified teaching design, 62 students) and one control group (without gamified teaching design, 62 students). The paired sample T test was used to compare the pre- and post-test scores of the learners, while the independent sample T test was used to analyze the learning engagement (behavioral, cognitive, and emotional engagement) of college students under gamified teaching using mobile technology. Results show no significant difference in pre-test scores between the experimental and control groups ($P = 0.374 > 0.05$), meeting the prerequisite for the comparative experiment. Gamified teaching using mobile technology found significantly improved test scores ($P = 0.003 < 0.05$), where independent sample T test results showed a significant difference in learning engagement (behavioral, cognitive, and emotional). After using gamified teaching using mobile technology, the experimental group of students showed a significant increase in learning engagement, which is consistent with the results of most of the literature. The results of this study have important reference value for school administrators to propose new teaching strategies and for teachers to integrate information technology to assist the teaching process, to propose solutions for building interactive teaching environments, and to alleviate the fatigue phenomenon that often occurs in the application of multimedia technology in current information technology teaching in universities.

KEYWORDS

mobile technology supported, gamified teaching, learning engagement, independent-sample T-test, paired-sample T-test

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1 INTRODUCTION

The accelerated development of China's educational informationization has promoted the modernization of educational content, teaching methods, and approaches, thereby encouraging students to learn through information technology and improve their ability to analyze and solve problems using information technology. With the advancement of information and communication technology, the concept of "Internet+" in traditional industries was proposed in 2012, leading to the emergence of a large number of online education products, and educational modernization was pushed to a new starting point. By making full use of modern information technology and continuously enriching and innovating the forms of courses, implementing heuristic, exploratory, and gamified teaching methods, students' innovative spirit and practical ability can be cultivated. Modern technology can be used to promote the reform of talent cultivation modes. Educational modernization is not only the result of scientific and technological development reaching a certain stage but also the need of the times. By combining traditional approaches with modern information technology, educators constantly improve teaching methods, actively explore educational modernization approaches, and make every effort to promote educational reform. Using mobile technology for communication and collaboration gives students an advantage. Mobile technology has become an essential resource in people's lives, and educational applications are closely related to day-to-day life. Users can use application software at any time and any place to strengthen the connection between new and old knowledge. Second, mobile technology provides an effective medium for interactive teaching. Various software applications are installed on mobile devices, and users can quickly interact with information through mobile devices. In the traditional classroom environment, all electronic devices that do not involve learning are prohibited. In the rapidly developing Internet era, prohibiting students from using electronic devices in class is an outdated practice. A large number of domestic and foreign educational practices have also proved that the use of electronic devices in the classroom cannot be eliminated. Instead of trying to prohibit students from using their mobile phones in class, the mobile devices should be used for teaching.

Gamified teaching, one of the learning strategies, is the process of integrating game elements such as points, rankings, and badges into the teaching process. When designing teaching, one needs to learn gamification from the perspectives of cultivating goals, and developing and evaluating methods, learner psychological characteristics, and teaching strategies. Gamified teaching is an interactive process of teaching and learning. It adds game elements, attributes, and rules to the design and development of teaching activities, and absorbs knowledge from the learning process. Gamified teaching introduces game thinking, and game design forms into education and teaching, making learning a very attractive and effective activity process and mobilizing the initiative of learners to actively learn, thereby achieving satisfactory results. Game-based learning uses game elements to make learning more engaging and effective. Learning engagement refers to the level of attention, effort, curiosity, interest, and passion that students exhibit during active or passive learning processes. It encompasses interplay and influence between behaviors, emotions, and cognition in the learning process, and all three are equally important. Hence, using game-based learning activities can have a positive impact on improving students' learning performance and significantly increase their level of learning engagement, especially in higher education.

2 THEORETICAL FOUNDATION AND LITERATURE REVIEW

2.1 Theoretical foundation

Deci [1] believed that self-determination theory is a popular, research-based psychological theory. This theory can be used to study in detail the motivation of learners in different contexts, including educational ones. Self-determination theory is also widely used in gamification research. As a motivational theory, self-determination theory systematically explains the mechanisms of human needs and motivation in social and cultural backgrounds. This theory suggests that all individuals have three innate needs: the need for autonomy (feeling in control of their behavior and goals), the need for competence, and the need for relatedness. Compared with learners who are motivated by external conditions, learners who are driven by intrinsic motivation will achieve better learning outcomes and higher grades, and participate in learning more frequently. By contrast, external regulation and introjected regulation are closely related to low levels of psychological health, lack of perseverance, and poor performance.

Brown [2] regarded activity as an inseparable part of learning, meaning that learners acquire knowledge through learning activities in certain contexts and that context is an important aspect of learning. Situated learning theory suggests that the learning process is a dynamic interaction between knowledge and social contexts. The theory believes that learning occurs within a context, following learning activities, and results in the acquisition of knowledge. Knowledge is not imparted but acquired through autonomous construction within a given context by the learner. To learn a certain piece of knowledge, learners need to face the context in which the knowledge is applied and continually think about what knowledge they need to acquire to achieve their goals. By systematically thinking about a problem, learners will actively learn within the problem-solving context and thus achieve knowledge construction. The creation of situational stories can be used for a course or a specific teaching activity. For online courses, applying situational stories in course or teaching design by designing a systematic, continuous, and closely related story plot for students has many benefits. Students can enter the situation, increase their immersion and integration, perceive and understand problems and tasks encountered by different roles in situational stories, and fully consider the background of problems and tasks, thereby stimulating intrinsic motivation. Thus, students can utilize learning scaffolds provided by other roles to solve problems, thereby promoting knowledge transfer.

2.2 Literature review

The use of mobile technology in teaching environments has expanded the scope of traditional teaching interactions. By using mobile interactive applications, the limitations of time and space have been overcome, and the interactivity of classrooms has been improved. With the support of rich learning resources and mobile technology, the engagement of teachers and students in design can achieve a unique blend of virtual and real-world interactive learning. In terms of how gamification in mobile technology-supported teaching affects learning engagement and outcomes, Urh [3] proposed a model for introducing gamification into higher education e-learning. By appropriately integrating gamification into higher education, positive effects can be

produced in the learning process, such as increasing student satisfaction, motivation, and participation. Donnermann [4] conducted a systematic investigation of the combination of gamification elements and social robots in learning scenarios using a 2×2 design and found that the combination of these two added features led to an interactive effect and lower stickiness. Dicheva [5] conducted a systematic analysis of gamification in education and found that it can promote learners' motivation to some extent. Dehghanzadeh [6] argued that digital gamification is considered an interesting and enjoyable method to support learning English as a second language and can bridge the gap between students' learning and educational practice. Palaniappan [7] measured the impact of gamification on learners' academic performance and investigated their level of self-directed learning in an online gamified learning environment. The results showed that learners' academic performance significantly improved after the implementation of gamification, and the gamification strategies used in the online learning environment had a positive impact on supporting learners' self-directed learning. Su [8] explored how gamification teaching methods affect science learning, achievement, and motivation through a context-aware mobile learning environment. Survey responses indicated that students highly value outdoor learning activities using smartphones and their functions. Compared with non-gamified mobile learning or traditional teaching, combining mobile and gamification technology in botany learning can lead to better learning performance and higher levels of motivation. Tsay [9] found that students who participate in gamified systems achieve significantly higher grades than those who participate in non-gamified traditional teaching, and online learning behavior participation is positively correlated with course performance. Villagrasa [10] described the application of gamification and visual technology in higher education classrooms. Combining teacher support with new and accessible technology can assist classroom gamification and help learners achieve better results during the learning process. Almeida [11] used a qualitative approach based on a case study of 25 innovation projects in Portuguese higher education institutions. The results showed that gamification brought benefits to the educational environment, including increased student engagement, skills development, and skills application in real-world settings. Alabbasi [12] found that both in- and pre-service teachers had a positive attitude toward using gamification tools and online course design features in online learning. Mazarakis [13] suggested that gamification in teaching can effectively increase student motivation and promote learning. Qiao [14] used an explanatory sequential mixed-methods design to randomly assign two high school classes to either a mixed (N=52) or non-digital (N=52) gamification condition. Their quantitative results indicated that the two methods have the same degree of improvement in students' learning outcomes, and the improvement in students' cognitive engagement is significantly greater in the mixed gamification condition than in the non-digital condition. Mee [15] believed that with the support of technological development, the concept of gamification has been widely spread, and proposed a simulated gamification conceptual model to improve the motivation and attitude of primary school learners. Duggal [16] designed and implemented a gamification framework for 120 higher education students, and the results showed that gamified teaching can enhance students' engagement, appeal, and motivation. Bouchrika [17] found that gamification can be considered a valuable tool that can attract users to accept educational systems and increase their interactivity and participation. Jayalath [18] proposed 15 game dynamics, relevant mechanisms, and appropriate game components, suggesting embedding game components during the implementation phase of providing learning opportunities to motivate and engage learners to attain the desired competencies. Alsubhi [19] advocated the use of a large number of game elements in gamifying e-learning, identifying several game elements that are suitable to include in learning activities on e-learning

platforms to increase student engagement. The literature indicates that using mobile technology and game-based learning through existing educational apps can assist teachers in interactive classroom teaching, providing feasible solutions to enhance classroom interaction and collect student feedback information. Different teaching methods and activities can help teachers choose suitable mobile technology-assisted gamification teaching methods for teaching interactions, which can achieve student–teacher interaction, peer-to-peer interaction, teacher–resource interaction, and human–machine interaction in the classroom and enhance learners' investment in learning. Most of the extant studies focus on the impact of gamification on learning engagement in traditional classroom environments, with less research on gamification teaching supported by mobile technology. This study attempts to use mobile technology to build an interactive teaching environment to assist gamified teaching from a new perspective, aiming to address the issue of multiple interaction gaps in classroom teaching. This can facilitate the immediate collection of student feedback information and present it to teachers in a visualized manner for precise diagnosis and management of students' online learning.

3 METHODOLOGY

3.1 Research subjects

This study conducted experimental research on 124 undergraduate students majoring in Civil Engineering from Harbin University of Science and Technology in Heilongjiang Province.

3.2 Research design

This study randomly assigned one teaching class for the Civil Engineering majors from Harbin University of Science and Technology as the experimental group (with game-based teaching design, 62 students) and one teaching class as the control group (without game-based teaching design, 62 students). Before conducting game-based teaching practice, the students in both experimental and control groups of each university were taught scientific courses for one month using traditional blended teaching methods by the same instructor. To further understand the basic knowledge of science courses mastered by the students in the experimental and control groups and to eliminate interference from irrelevant variables to the greatest extent possible, a test of civil engineering common knowledge was conducted using a percentage-based examination format before the start of game-based teaching practice. In the second phase, a comparative experimental method was mainly adopted. The control group continued to use the traditional hybrid teaching method used previously, while the experimental group adopted gamified teaching and made full use of software such as Xueersi and Class Optimization Master to assist in implementing gamified teaching. After the practice was completed, data such as post-class gamified exercises and classroom videos were collected, and a learning input scale was filled out to investigate the learners' learning input, obtaining raw data on learning input. At the same time, after the experiment ended, a final exam was conducted to assess the knowledge mastery level of students in both the control and experimental groups, and a comparative analysis was performed on the pre- and post-test scores. The test questions were designed by a veteran teacher who had been teaching the

subject for more than 20 years. The questions were confirmed by two other experts after modification. Before the test began, another class was selected for testing.

3.3 Research tools

For this study, we used the three-dimensional framework for learning engagement proposed by Fredricks [20]. The learning engagement questionnaire consists of three dimensions: behavioral, cognitive, and emotional engagement. Each dimension is further divided into sub-dimensions, which include 5, 6, and 7 questions, respectively. Responses were scored on a Likert scale of 1–5, ranging from strongly disagree to strongly agree.

4 RESULT ANALYSIS

4.1 Pre-test analysis

Before the implementation of game-based teaching, a pre-test was conducted to assess the students' science foundation in both the experimental and control groups. A two-sample independent T test was conducted, and the descriptive statistics of the test results are shown in Table 1.

Table 1. Pretest scores of experimental group and control group

Sample	Mean	Standard Deviation	Mean Standard Error	T Value	Degrees of Freedom	P Value
experimental group pre-test scores	63.04	7.87	1.0	–0.89	120	0.374
control group pre-test scores	64.38	8.76	1.1			

Table 1 shows that the average scores of the two groups in the pre-test are not significantly different. After verifying that the scores of both groups followed a normal distribution, an independent sample T test was conducted. The result shows that the significance value is 0.374 > 0.05, indicating no remarkable difference between the scores of the experimental group and the control group. The scientific knowledge level of the two classes of students in civil engineering fundamentals is therefore not significantly different, and the comparative experiment of gamified teaching can be conducted with these two classes.

4.2 Pre-test and post-test score analysis

Table 2. Post-test scores of experimental and control groups

Sample	Mean	Standard Deviation	Mean Standard Error	T Value	Degrees of Freedom	P Value
experimental group post-test scores	69.49	7.79	0.99	3.00	121	0.003
control group post-test scores	65.31	7.71	0.98			

Table 2 shows that the average score of the experimental group in the post-test was significantly higher than that of the control group. Using IBM SPSS 23.0, an independent sample T test was conducted on the post-test scores of the two classes, with a P value of 0.003 < 0.05, indicating a significant difference between the post-test scores of the control and experimental groups. This suggests that gamified teaching has a significant effect on improving test scores.

Table 3. Paired sample T test of pre-test and post-test scores for the experimental and control groups

Sample	Mean	Standard Deviation	Mean Standard Error	T Value	P Value
experimental group pre-test scores	63.04	7.87	1.00	–59.56	0.000
experimental group post-test scores	69.49	7.79	0.99		
control group pre-test scores	64.38	8.76	1.11	–0.63	0.534
control group post-test scores	65.31	7.71	0.98		

Table 3 shows that the P value of the paired-sample T test for the pre- and post-test scores in the experimental group is 0.000, which is less than 0.05. This indicates that the use of gamified teaching with mobile technology support can significantly improve the learning performance of students in the experimental group. The P value of the paired-sample T test for the pre- and post-test scores in the control group is 0.534, which is greater than 0.05. This suggests that the use of traditional teaching methods did not result in a significant improvement in learning performance for learners.

4.3 Behavioral engagement analysis

To explore the differences in student behavioral engagement in specific dimensions of different teaching designs, independent sample T tests were conducted on the behavioral engagement questionnaire data for both groups.

Table 4. Analysis of differences in behavioral engagement

Sample	Mean	Standard Deviation	Mean Standard Error	T Value	Degrees of Freedom	P Value
experimental group behavioral engagement	20.29	1.41	0.18	17.41	102	0.000
control group behavioral engagement	16.61	0.88	0.11			

Table 4 shows that the independent sample T test results show that the P value of behavioral engagement is 0.000 < 0.05, indicating a significant difference in behavioral engagement between the experimental and control groups after the students in the experimental group adopted the gamified teaching method with mobile technology support. This instructional design helps to improve student behavioral

engagement. The main reason is that gamified teaching can significantly enhance learning motivation. After the learning motivation becomes stronger, learners are more willing to adopt gamified teaching methods and actively explore certain things or behaviors. Students with a strong learning motivation have higher levels of learning persistence and learning output. Gamified teaching activities also help to stimulate students' curiosity and desire for knowledge, benefiting the development of subject teaching. Students like games. Gamified teaching, by creating situations related to students' daily lives, setting game tasks with varying difficulty levels, and using role-playing mechanisms and task-driven mechanisms, has a great attraction to students, thereby increasing their behavioral engagement.

4.4 Cognitive engagement analysis

To explore the differences in the cognitive engagement of students in specific sub-dimensions under different instructional designs, independent sample T tests were conducted on the cognitive engagement scale data of the two groups.

Table 5. Analysis of differences in cognitive engagement

Sample	Mean	Standard Deviation	Mean Standard Error	T Value	Degrees of Freedom	P Value
experimental group cognitive engagement	26.21	2.18	0.28	17.66	113	0.001
control group cognitive engagement	20.07	1.65	0.21			

Table 5 shows that as per the independent sample T test results, the P value of cognitive engagement is 0.001 < 0.05, indicating a significant difference in cognitive engagement between the experimental and control groups after the students in the experimental group adopted the gamified teaching method with mobile technology support. This instructional design helps to improve student cognitive engagement. The main reason is that gamified teaching activities are not just about playing games but rather a transformative approach that uses game elements as the foundation and innovative elements to construct a new student-centered educational ecosystem. Game elements mainly include players, referees, game activities, and game tasks. Different from the design of traditional teaching activities, gamified teaching strengthens and improves teaching elements through game elements. Students are both learners and players of the game, and it is necessary to comprehensively analyze their game-carrying capacity, strengthen the active relationship between teaching content and game tasks, and combine teaching goals with game goals to design gamified teaching activities. Therefore, gamified teaching can stimulate students' intrinsic motivation from external stimuli, which is conducive to increasing learners' initiative and making them take learning tasks more seriously.

4.5 Emotional engagement analysis

To investigate the differences in emotional engagement of students in specific dimensions under different teaching designs, an independent sample T test was conducted on the emotional engagement scale data of the two groups.

Table 6. Analysis of differences in emotional engagement

Sample	Mean	Standard Deviation	Mean Standard Error	T Value	Degrees of Freedom	P Value
experimental group emotional engagement	29.82	2.62	0.33	10.70	113	0.000
control group emotional engagement	25.37	1.97	0.25			

As per Table 6, the results of the independent sample T test show that the P value of emotional engagement is 0.000 < 0.05, indicating a significant difference in emotional engagement between the experimental and control groups after adopting the gamified teaching method supported by mobile technology. This teaching design helps to improve student emotional engagement. The main reason is that applying gamified teaching activities to traditional engineering courses such as civil engineering aims to enhance student learning motivation, thereby promoting better learning and development. Therefore, in the implementation process of gamified teaching activities, students should always be the subject of the learning activity. Student participation is essential in gamified teaching activities, and teachers should pay attention to changes in student learning behavior and provide timely feedback. Students are the recipients of teaching activities, and they can maintain good activity records on their own feelings or unsolved problems they encounter, fully realizing that students are the subject of learning. After class, they can actively communicate with teachers to jointly improve teaching activities and achieve teaching goals, conducting sufficient emotional exchanges between teachers and students and among students. Therefore, gamified teaching design has a positive effect on improving learners' emotional engagement, reducing their anxiety, and enhancing their sense of achievement.

5 DISCUSSION

With the rapid development of mobile communication technology and network technology, mobile technology has gradually penetrated various fields of social life. The use of mobile technology in classroom teaching has also been highly valued by scholars. Spikol [21] noted that when mobile technology has become an essential tool for our daily learning and life, we should guide students to use mobile technology for learning, making it easier for them to make full use of mobile technology to make learning more efficient. Zou [22] reported that mobile technology has brought convenience to students' blended learning. Students can easily communicate and access the internet through mobile devices. The mobile learning environment provides learners with different learning experiences. With the help of mobile devices, students' learning places are no longer limited to the classroom, and they can learn and participate in teaching activities at any time and at any place. However, as a learning model that breaks time and space barriers and can carry out educational activities under synchronous or asynchronous conditions between teachers and students in different spaces, mobile learning, due to its autonomy and convenience, introduces difficulties in paying attention to learners' learning status promptly, and the actual input status is also difficult to grasp. The effectiveness of online learning directly affects

students' learning quality. As an essential part of the implementation process of the core concept of education informatization, innovative information technology teaching models are needed to teach students in ways they like. Gamified teaching is beneficial to improve students' logical thinking ability and cultivate their hands-on ability and communication skills to quickly solve practical problems. Based on game-based learning, focusing on students' objective needs and the development of their thinking and paying attention to breaking through the barriers between students' reality and new knowledge, students can use the teaching context created by gamified teaching to express and share, and to design game tasks that are combined with specific fields. Thus, they can create vivid and enjoyable teaching contexts to attract students' attention. The characteristics of gamified teaching meet the growth needs of students in the learning process and promote innovative thinking and awareness. The learning methods supported by mobile technology are becoming increasingly diverse.

6 CONCLUSIONS

With the widespread use of mobile technology in our lives, many scholars have begun to pay attention to the practical application of mobile technology in classroom teaching and have tried to find new methods between information technology and different teaching methods (such as gamification teaching) by using mobile technology. The rapid development of mobile technology and its frequent application in classroom teaching will bring about great changes to classroom teaching. Teachers can change their traditional teaching concepts and gamify teaching using mobile technology, which can better adapt to the teaching method changes brought about by the new teaching environment and enhance the learners' engagement in mobile learning. In this study, 124 undergraduate students majoring in Civil Engineering from Harbin University of Science and Technology in Heilongjiang Province were randomly assigned to an experimental group (62 students) and a control group (62 students). A paired sample T test was conducted on the pre- and post-test scores of the learners, and an independent sample T test was conducted on the learners' engagement in mobile technology-supported gamified teaching. The results show the following: (1) There was no significant difference in pre-test scores between the experimental group and the control group ($P = 0.374>0.05$). (2) Mobile technology-supported gamification teaching had a significant effect on improving test scores ($P = 0.003<0.05$). (3) There were significant differences in the three dimensions of engagement (behavioral, cognitive, and emotional), and the learners in the experimental group showed a significant increase in engagement after using mobile technology-supported gamified teaching. Future researchers are recommended to investigate the rationality of constructing teaching environments in mobile interactive environments, the evaluation of the effect of mobile interactive technology on classroom teaching, and the factors affecting learners' engagement in blended gamified learning environments.

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