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PAPER

Effectiveness of Online Collaborative Learning in Gamified Environments

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ABSTRACT

Online education, supported by emerging technologies, such as the Internet, big data, and industrial intelligence, is becoming a growing trend. Gamified learning is gaining popularity within educational environments. Educational games serve as the medium for this type of learning and as tools to support learning. They create real-world situations for students to solve tasks, effectively cultivating problem-solving, critical thinking, and creativity skills. In gamified teaching, collaborative learning helps players in completing game tasks by focusing on cooperation and learning essential knowledge or skills. This study selected 300 students from Harbin University of Science and Technology as research subjects. A single-factor, two-level between-subjects design was used to examine the influence of online collaborative learning (independent variable) on flow experience, intrinsic motivation, and academic performance (dependent variables). The participants were divided into an experimental group (two-player collaborative game group, N = 150) and a control group (single-player game group, N = 150). After completing their assigned tasks, the participants independently completed questionnaires and tests. Data were then analyzed using SPSS 25.0 software. Results show that there is no significant difference in prior knowledge between the two groups. However, notable differences are found in flow experience, intrinsic motivation, and academic performance. The experimental group demonstrates significantly better academic performance than the control group, indicating the effectiveness of collaborative learning within gamified learning. Flow experience has a partial mediating role in collaborative learning, whereas intrinsic motivation has a full mediating role. These findings have critical implications for understanding the impact mechanism of collaborative learning on academic performance in gamified learning, promoting the effective utilization of educational games, and accelerating the exploration and application of gamified learning models.

KEYWORDS

online collaborative learning, gamified learning, flow experience, intrinsic motivation, academic performance

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1 INTRODUCTION

The extensive distribution of educational information has led to the widespread adoption of online learning, which is instrumental in promoting sustainable lifelong learning. As one of the primary approaches to online learning, online collaborative learning enables learners to acquire knowledge while developing their ability to communicate and collaborate with their peers. The extensive involvement of the Internet has enabled online collaborative learning to emerge as a key form of collaborative learning, supported by computer technologies. This learning method integrates online and offline teaching and serves as an innovative teaching model that allows learners to access and assimilate more knowledge, and interact with others. It also expands students' horizons and cultivates a diverse range of cognitive skills, such as innovation, critical thinking, higher-order cognition, and collaborative creativity. Although learners participating in online collaborative learning come from diverse backgrounds, they share common learning goals. Each participant assumes a distinct role in the collaborative learning process, utilizing their peers' strengths to accomplish complex tasks as a team. However, the specific nature of online collaborative learning presents challenges to learners who lack face-to-face communication. To address these difficulties, teachers organize students into groups, assign different roles to group members, and encourage communication and collaboration to work effectively together while fostering a robust sense of teamwork.

Online education's growth, fueled by the Internet, big data, industrial intelligence, and other technologies, has, in turn, nurtured new technologies. The advancement of modern technology, combined with students' desire to explore knowledge, has continually challenged traditional teaching models, giving rise to innovative teaching approaches, such as gamified learning, online learning, micro-courses, and flipped classrooms. Particularly, gamified learning has gained increasing popularity in educational settings, and educational games have become a medium for this learning approach by serving as teaching tools. The information technology revolution has led to the widespread adoption of games as an advanced technology that transforms teaching and learning strategies. Gamified learning creates immersive, appealing, and enjoyable activities, where challenging objectives are pursued within established rules. This learning method offers unique characteristics difficult to replicate in traditional classrooms. First, games provide goals, problem-solving opportunities, outcomes, and feedback that allow students to develop useful mental models for learning. Second, games are interactive, allowing students to participate in learning activities and actively seek solutions. Lastly, games elicit different emotions and experiences by involving students in plots and real-life situations. Students have become the central focus of learning in the digital education era, which has led to a shift from teachers as traditional knowledge transmitters to facilitators in information-based classrooms. Therefore, conducting teaching experiments guided by relevant theoretical models to investigate the effect of collaborative learning on academic performance in gamified learning helps promote the effective use of educational games and accelerates the exploration and application of gamified learning models.

2 STATE OF THE ART

The proliferation of information technology has prompted the increasing application of games in educational settings. As an advanced technology, games have fundamentally transformed strategies for teaching and learning. To enhance the effectiveness of gamified learning, assistance and guidance can be provided during

the learning process to facilitate learners' engagement with the required cognitive processes and reduce their cognitive load. As such, online collaborative learning enables learners to pool their ideas, information, experiences, skills, and abilities to achieve common goals. In view of gamified learning, collaborative learning has been identified as an approach to support learners in completing game tasks. The inherent equivalent of collaborative learning in traditional classroom settings refers to the interaction among students. As to how online collaborative learning affects gamified learning outcomes, Azmi [1] outlined how to embed gamification in online collaborative learning to increase the participation of new student programmers. The results showed that embedding game elements within online collaborative learning significantly improved the participation of student programmers. Li [2] held that gamification can effectively attract existing and new users, analyzed an online social network of computer science majors, and evaluated the effectiveness of collaboration in online gaming. Uz Bilgin [3] stated that collaborative learning has shown promising results as an innovative teaching methodology and compared a gamified group (44 students) to a traditional group (48 students) in a quasi-experimental design study. The results indicated that the gamified group outperformed the traditional group in group cohesion scores and team member evaluations. Sharkova [4] proposed a gamified learning approach and tested it on 93 university students. The results demonstrated that gamified collaborative learning can be a powerful and effective incentive and pedagogical tool if properly implemented. Nofal [5] utilized a hybrid approach to evaluate how tangible gamification techniques can entertain and educate 15 students in a maximum of 15 minutes. The findings indicated that gamification techniques can promote participation and collaboration by fostering a sense of ownership and design diversity. Bhati [6] held that higher education should now provide network and mobile technology for college students to improve their learning environments. Wang [7] stated that cooperative learning can promote both teaching quality and learning efficiency. Knutas [8] argued that the benefits of collaborative learning have been established and gamification has been used to motivate students to achieve course goals in educational contexts. To this end, an evidence-based approach and case study were presented, employing interaction analysis and k-means clustering to generate gamification preference profiles. Betts [9] provided a succinct account of the creation of a collaborative learning environment to enhance online learning participation. The outcomes indicated that gamification can contribute to fostering positive learning experiences and student group performance. Wang [10] adopted a gamified teaching mode—the CSLS teaching mode—to design a collaborative learning activity to support the learning of organic compounds. A comparative experiment was conducted with a total of 72 students from a high school in northern Taiwan. The results showed that students under the gamified learning mode achieved significantly better academic performance compared with peers under the traditional classroom teaching mode. Garcia-Sanjuan [11] presented Quizbot, a collaborative gamified quiz application, and examined how it influences the effectiveness of gamified learning. The results indicated that Quizbot exhibited comparability between entertainment and usability, and represented an effective tool for supporting collaboration between children, facilitating their processes of reaching consensus through discussions, dividing tasks to work in parallel, and respecting one another. Martí-Parreño [12] found that teachers perceive gamification as a promising strategy to enhance student development and thus recommended that higher education teachers and policymakers encourage the implementation of gamified curricula to foster student competencies. Barneva [13] explored novel instructional methods to enhance and promote collaborative learning in modern technology classrooms. The author found that through

mobile applications on students' smartphones, augmented reality views can further enhance the information presented on digital surfaces, proposing a method to strengthen the teaching process.

The above studies indicate that collaborative learning has a significantly positive effect on academic performance in gamified learning. Moreover, substantial evidence suggests that students' motivation and flow experience in gamified learning positively affect their academic performance, where high levels of motivation and flow experience are associated with improved academic performance. However, the effect of collaborative learning on flow experience and motivation in gamified learning is inconsistent, which may affect its influence on academic performance. Academic performance represents a crucial indicator for evaluating students' achievement of learning objectives. The efficacy of an effective online learning platform is contingent upon whether learners can accomplish prescribed learning objectives. However, given the multitude of interpretations of learning outcomes among scholars, the influence of collaborative learning within gamified learning on motivation, flow experience, and academic performance must be examined.

3 METHODOLOGY

3.1 Research method

A single-factor, two-level, between-subjects design was implemented, with the independent variable being the presence or absence of collaborative learning. Based on previous research regarding participant allocation, the experimental group participated in collaborative gameplay, whereas the control group took part in individual gameplay. Although the type of collaborative learning does not produce variance in academic performance, offline collaborative learning poses fewer technical challenges and negates the need for substantial physical, material, or financial investment when incorporating collaboration into gamified learning activities. By selecting suitable educational games, collaborative learning activities can be conducted during their usage. Individual testing was utilized to measure students' academic performance under collaborative conditions. The control group's conditions were identical to those of the experimental group, except for the absence of collaboration.

The dependent variable, gamified academic performance, was assessed comprehensively from three aspects: flow experience, intrinsic motivation, and academic performance. The five-question survey questionnaire by Lee [14] was used to measure flow experience. To gauge intrinsic motivation, 6 out of 15 questions from Logan's [15] survey questionnaire were chosen based on this study's research objectives. Academic performance was assessed using test scores, consisting of online gaming performance scores and offline paper test scores, each accounting for 50%. The independent variable, online collaborative learning, was measured using the five-question questionnaire by Razali [16]. All survey questionnaires were administered using a five-point Likert scale.

3.2 Research process

Pretest stage: The pretest questionnaire mainly included demographic variables (e.g., major, grade, and gender) and a prior knowledge questionnaire.

Game introduction stage: The experimenters gave a 10-minute introduction to both groups of participants, showed the game interface and required game tasks, demonstrated the operation process, and instructed all the participants to play three rounds of the game.

Experimental stage: During the experiment, participants in the experimental group were seated together to play the game and were required to engage in active discussions during the game. The participants in the control group individually completed the game tasks at their own pace. The game duration was approximately 25 minutes, and any participants who had not completed their tasks by the end of the allotted time were instructed to stop playing the game.

Posttest stage: After the game, all the participants were asked to complete the intrinsic motivation scale, flow experience scale, academic performance test, and collaborative learning style questionnaires. The entire process took approximately 15 minutes.

3.3 Research subjects

A total of 300 undergraduate students from Harbin University of Science and Technology were selected as participants in this study. All students were familiar with computers and had not previously played the game used in this research. A single-factor, two-level, between-subjects design was employed, and the students were assigned to either the experimental group (two-player collaborative gaming group, 150 students) or the control group (single-player gaming group, 150 students). Students in the experimental group played the game in pairs, with the freedom to discuss and assist each other during the game. Conversely, students in the control group completed the game task individually and were not allowed to seek help from others. The experimental teaching took place during the spring semester of 2022 and spanned 8 weeks. After completing the game tasks, all participants independently completed the questionnaires. The experimental data were analyzed using SPSS 25.0.

4 RESULTS ANALYSIS AND DISCUSSION

4.1 Analysis of pretest scores

Before the experiment, an analysis using SPSS 25.0 was conducted to compare the average final exam scores of the experimental and control groups from the previous semester to assess whether the overall proficiency levels of both groups were comparable. The results indicate that the students' general academic performance remains consistent, with similarly matched test scores.

Table 1. Analysis of pretest scores of the experimental and control groups

Groups (Mean ± Standard Deviation)	Pretest Scores
Experimental group (N = 150)	75.72 ± 8.32
Control group (N = 150)	75.79 ± 8.53
t	–0.069
p	0.945

Table 1 shows that the significance level of scores for the experimental and control groups is 0.945, with a p value distinctly greater than 0.05. Thus, no significant difference exists between the two groups' academic abilities, meeting the fundamental prerequisite for the teaching experiment.

4.2 Analysis of differences between the experimental and control groups

Table 2. Differences between the experimental and control groups

Sample	N	Mean	Standard Deviation	Standard Error of Mean	t	p
Flow experience of experimental group	150	21.427	2.029	0.166	15.97	0.000
Flow experience of control group	150	17.937	1.659	0.135		
Intrinsic motivation of experimental group	150	27.588	1.476	0.121	29.03	0.000
Intrinsic motivation of control group	150	21.527	2.050	0.167		

Table 2 indicates the following:

(1) A significant difference in flow experience exists between the experimental and control groups, suggesting that online collaborative learning effectively enhances the flow experience of gamified learners. Numerous studies have established that the flow experience in gamified learning positively correlates with academic performance and predicts academic achievement powerfully. The current findings support this conclusion. One possible explanation is that gamified learning tasks may challenge students, creating an imbalance between skill and challenge, and thus introducing anxiety. However, under experimental conditions, subjects collaborate to complete game tasks and can overcome challenges through mutual aid and motivation, refining their abilities to tackle game tasks. This approach reduces the subjective difficulty, making subjects more engaged and responsive to the learning process, a state that aligns with flow. In this state, individuals are more likely to voluntarily participate in learning activities, repeat learning activities, persevere through challenges, and maintain focus on learning. Collaborative learning provides a platform for learners to communicate and discuss with one another, whereas educational games provide an ideal environment for these interactions. Educational games not only satisfy students' needs for socializing and self-expression but also enhance their flow experience, ultimately strengthening students' academic performance.

(2) A significant difference in intrinsic motivation exists between the experimental and control groups, implying that online collaborative learning effectively enhances the intrinsic motivation of gamified learners. In line with previous studies, this research found that collaborative learning in the context of gamified learning can increase learners' intrinsic motivation. Intrinsic motivation is an internal drive that stimulates and sustains individual behavior. Individuals with high motivation levels are more likely to persevere through challenges and actively engage with difficult tasks. In this study, the experimental group participated in collaborative gaming in pairs, potentially influencing students' learning objectives to focus more on the game's learning content rather than demonstrating their performance to peers. In addition, collaboration with peers helps learners experience a reduced level of challenge and increased confidence, which

bolsters their belief in their ability to complete game tasks, thereby stimulating their interest in learning and raising their motivation levels. During gameplay, when participants discuss the game with peers, they can more effectively manage their cognitive resources, contributing to their heightened motivation to learn. Thus, individuals engaged in collaborative gameplay may exhibit high levels of intrinsic motivation.

4.3 Analysis of posttest scores

Table 3. Analysis of posttest scores

Sample	N	Mean Value	Standard Deviation	Standard Error of Mean	t	p
Posttest scores of experimental group	150	82.581	6.875	0.561	11.14	0.000
Posttest scores of control group	150	71.318	9.667	0.789		

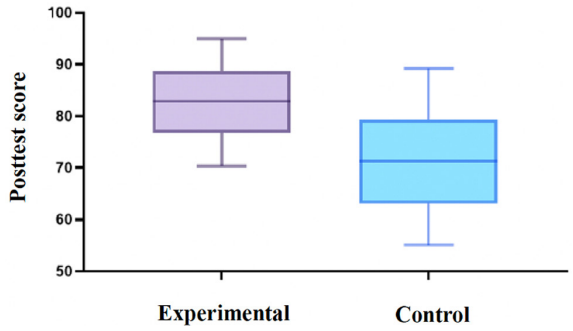

Fig. 1. Posttest scores (experimental and control groups)

Table 3 and Figure 1 demonstrate a significant difference between the posttest scores of the experimental and control groups, indicating the effectiveness of online collaborative learning in enhancing the posttest results of gamified learners. Online collaborative learning involves a critical aspect of collaboration, in which learners are guided by teachers to engage in a variety of communication activities, including Internet-based study and other tasks. During online collaborative learning, proper teacher guidance and mutual support between group members encompass the key aspect of collaboration, specifically cooperation and win-win outcomes. The importance of collaborative learning extends beyond promoting knowledge acquisition, fostering its application by learners, and suggesting its potential as a method for facilitating students' deep learning. The main reason for this is that the collaborative gaming mode creates a natural environment for communication in gamified learning. Students can exchange thoughts, behaviors, and perspectives on the game, share information and knowledge, generate new ideas to solve game tasks, and actively construct knowledge. This process also helps activate previous knowledge and experiences, enhance students' understanding of learning materials, internalize knowledge as their own, and enrich their existing knowledge structures. Under collaborative learning conditions, students can engage in discussions and negotiations, and work together to solve problems encountered in the game. Peer support and assistance improve learners' abilities, reduce frustration, and promote engagement, resulting in the successful completion of game tasks and learning objectives, and the acquisition of new knowledge. Particularly, working in pairs forms a small group with

a common goal of successfully completing game tasks. Motivated by this objective, group members encourage and support each other, stimulate learning motivation, improve group cohesion, promote individual and group performance improvement, and increase knowledge acquisition. Collaborative learning helps increase learners' cognitive resources for constructing conceptual models, which, in turn, produces greater cognitive abilities to improve learners' academic performance in the game.

4.4 Mediating effect analysis

Table 4. Mediating effect

Item	Collaborative Learning (Independent Variable) ≥ Flow Experience (Mediator) ≥ Academic Performance (Dependent Variable)	Collaborative Learning (Independent Variable) ≥ Intrinsic Motivation (Mediator) ≥ Academic Performance (Dependent Variable)
c	0.881**	0.232**
a	0.241**	0.214**
b	0.087*	0.828**
a×b mediating effect	0.021	0.177
a×b (Boot SE)	0.009	0.041
a×b (z value)	2.283	4.349
a×b (p value)	0.022	0
a×b (95% boot CI)	0.003 ~ 0.039	0.091 ~ 0.253
c direct effect	0.860**	0.054
Conclusion	Partial mediation	Complete mediation

Notes: c represents the regression coefficient of the independent variable (collaborative learning) to the dependent variable (learning achievement), that is, the total effect; a represents the regression coefficient of independent variables (collaborative learning) to mediating variables (flow experience and intrinsic motivation); b represents the regression coefficient of mediating variables (flow experience and intrinsic motivation) to dependent variables (academic performance); * and ** indicate significance at the 5% and 1% confidence levels, respectively.

Table 4 indicates the following:

(1) Flow experience plays a partially mediating role in promoting students' academic performance through collaborative learning, with its mediating effect being more pronounced between collaborative learning and posttest scores (knowledge retention and transfer). This finding aligns with Admiraal's [17] conclusions. The reason is that achieving flow during gameplay can result in long-term cognitive outcomes and foster students' progress. The game allows students to reach a flow state, become fully immersed in the game, and improve their academic performance. Moreover, encouragement and support from peers enable learners to enjoy the satisfaction of achieving high scores and easily progressing through levels.

(2) Intrinsic motivation plays a complete mediation role in promoting students' academic performance through collaborative learning. Collaborative learning indirectly influences students' academic performance through intrinsic motivation. In gamified learning, collaborative learning can enhance students' intrinsic

motivation, leading to improved academic performance. The main reason is that educational games provide students with a motivating and entertaining environment, stimulating their interest, participation, and motivation in collaborative learning. Furthermore, as an active learning strategy used in gamified learning, collaborative learning allows students to easily handle game tasks, correctly process presented information, experience a sense of control over the game, and feel elated by their victories. Consequently, this stimulation boosts learners' intrinsic motivation and encourages them to make a greater effort in learning. Moreover, students under collaborative learning conditions can control the learning process, approach challenges positively, and fully utilize various resources for learning, thereby maintaining satisfactory academic performance, even as task complexity in online learning increases.

In today's society, the use of educational games is becoming increasingly widespread, and more researchers are focusing on examining the effects of educational games on learning to develop superior educational games and implement gamified learning approaches more effectively in classrooms. Existing empirical studies have systematically established the positive effect of gamified learning, with researchers advocating for providing appropriate assistance and guidance during gamified learning processes to optimize educational games' effectiveness. In this context, the influence of collaborative learning on gamified learning has attracted scholarly attention. As a positive and effective learning approach, collaborative learning is known to significantly influence gamified learning. Liao [18] suggested that enhancing learning motivation and flow experience through peer assistance and support in collaborative gameplay can improve students' abilities, leading to a flow state despite the unchanging difficulty of game tasks. Plass [19] argued that individuals who enter a flow state tend to concentrate more on the game and are less likely to give up when faced with challenges, ultimately increasing their motivation to learn. In comparison with collaborative learning and flow experience, Moreno [20] posited that intrinsic motivation serves as the most proximal factor for academic performance. This finding supports motivational theories, which indicate that learners' interest in game content, perception of control over the games, and exhilarating experiences from victories result in increased learning efforts, positively affecting learners' academic performance. In addition, this study provides additional evidence of the positive influence of collaborative learning on academic performance. The conclusions align with previous research by Chen [21] and Bawa [22] demonstrating that collaborative gameplay significantly enhances students' academic performance compared with individual gameplay. This study comprehensively measures learning effects from three perspectives: flow experience, intrinsic motivation, and learning performance. It systematically addresses the overall influence of collaborative learning in gamified learning on learning effects, whether collaborative learning can significantly improve learning effects, and the specific mechanism through which collaborative learning exerts its influence on learning performance.

5 CONCLUSIONS

With the rapid development of emerging technologies, such as big data, artificial intelligence, and 5G communication technology, online collaborative learning has emerged as a primary form of collaborative learning. By integrating online and offline teaching, online collaborative learning has evolved into a novel teaching

model that enables learners to access, learn, and interact more effectively with one another. This study involved 300 university students from Harbin University of Science and Technology as subjects and implemented a one-factor, two-level between-subjects design. The independent variable was the presence or absence of collaborative learning, and the dependent variables were flow experience, intrinsic motivation, and academic performance. Students who knew each other well were assigned to the experimental group (N = 150), whereas the remaining students were assigned to the control group (N = 150). The findings are as follows:

(1) Significant differences in flow experience, intrinsic motivation, and academic performance are observed between the experimental and control groups.
(2) The academic performance of the experimental group significantly surpasses that of the control group, indicating the effectiveness of collaborative learning in gamified learning environments.
(3) Flow experience plays a partial mediating role in promoting learning outcomes through collaborative learning, whereas intrinsic motivation plays a complete mediating role in enhancing learning outcomes through collaborative learning.

In light of these findings, further research is recommended to investigate potential individual cognitive differences in the influence of collaborative learning on academic performance, explore similarities and differences in learners' behavioral intentions during gamified learning, and compare learners' behavioral intentions in gamified learning across different subjects.

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