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Exploring the Impact of Game-based Learning on Students' Creativity from the Perspective of Interest, Relationship and Opportunity

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Abstract: Game-based learning has become an important trend in artificial intelligence assisted teaching. Based on the framework of connected learning, this study analyzes the influence mechanism of game-based learning on students' creativity from three aspects of interest, relationship and opportunity, and concludes that game-based learning, as a form of constructivist learning, can better promote connected learning. In this study, 56 students in Z province of China were investigated by questionnaire, and SPSS 23.0 and smart pls were used for statistical analysis. The results show that interest (academic interest and technical interest), relationship (collaborative tasks and common goals) and opportunity (learning time and learning cost) have a significant positive impact on the level of creativity improvement in game-based learning. In addition, self-efficacy can also play a significant positive role in the creativity of game-based learning. The research can help students better participate in game-based learning and master knowledge, and link students' in class learning and extracurricular learning, stimulate students' learning motivation, enrich classroom forms, and create a good learning environment.

Keywords: Game-based Learning; Connected Learning; Creative Ability; Information Technology

1. Introduction

In recent years, games have been widely recognized as essential to the development of teenagers. It provides a way for children to explore the world and acquire knowledge about how society works (Gros, 2007), which can help teenagers understand and explore the world, and stimulate their natural curiosity (Undiyaundeye, 2013). But for many teenagers, the opportunity to play has become increasingly scarce (Essame, 2020). Game-based learning refers to learning in a gamified way relying on modern educational technology. Game-based learning integrates numerous applications such as social media and digital software (Karaganis, 2007). Orlikowski & Scott (2008) pointed out that game-based learning integrated by digital platforms and virtual communities is a value embodiment of creative digital learning. Dougherty (2013) believes that game-based learning can promote the technology and ability of students to use information technology and support the development of students' maker thinking. Therefore, game-based learning is indispensable in the comprehensive training requirements of today's teenagers.

However, the current research is limited to the design and development of game-based learning, and it has not effectively combined with instructional design theory to analyze learning. Therefore, according to the interconnected learning framework of Ito et al. (2013), learners' in-class learning should be better

interconnected with their extracurricular learning. Rapeepisarn et al. (2006) pointed out that peer supported game-based learning relies on technology and can effectively become a teaching strategy combining learning activities in and out of class. Laakso et al. (2021) believes that when students can use their extracurricular interests and skills in in-class learning, learning engagement and creativity will be enhanced.

Therefore, the research aims to provide structured teaching support for improving students' creative ability and research ability of information technology (Hakkarainen et al. 2000), and effectively link students' learning in and out of class. This study investigated the game-based learning in which college students participated and constructed a structural equation model based on the connected learning framework to combine the improvement of creativity from game-based learning with connected learning. To sum up, this study raises two research questions:
Q1: Do interests, relationships and opportunities influence students' creativity in game-based learning? Q2: In what ways should students, parents and teachers combine connected learning with game-based learning?

2. Literature Review

2.1 Connected Learning

Connected learning can effectively combine the three parts of personal interest, support relationship and learning opportunities, which is fundamentally based on the constructivism theory (Fosnot, 2013). Ito et al. (2013) believes that connected learning should be based on and motivated by students' interest in funding, while Maul et al. (2016) pointed out that connected learning should be supported by peers and other learners and oriented to support students' academic research. At the same time, Ito et al. (2013) pointed out that the connected learning framework involves three design principles. First, collaborative activities should focus on advancing a common purpose. Second, focus on creating tangible products. Third, open networking so that everyone has the opportunity to participate in and access distributed cognitive resources. Therefore, connected learning emphasizes the importance of student participation in learning and creating collaboration. Hughes-roberts et al. (2020) pointed out that game-based learning based on connected learning can provide inspiration and encouraging learning experience for different learners. Based on the above discussion, Hypothesis 10, Hypothesis 11 and hypothesis 12 are proposed in this study:

H10: Personal interest has a positive impact on game-based learning creativity.
H11: Peer relationship has a positive impact on game-based learning creativity.
H12: Learning opportunities have a positive impact on game-based learning creativity.

2.2 Interest

In game-based learning, students' personal interest includes academic interest, artistic interest and technical interest. Dotterer et al. (2009) pointed out that adolescents' academic interest generally declined over time, and the decline in adolescents' academic interest was related to the decline in school performance. Silvia (2005) pointed out that artistic interest can affect the cognitive evaluation of adolescents, and the relationship between people is not regulated by individual differences related to artistic interest. Buccheri et al. (2011) pointed out that while interest in specific technologies can support career choices in some technical fields, gender plays a limiting role. Based on the above discussion, H1, H2 and H3 are proposed in this study:

H1: Academic interest has a positive impact on personal interest.
H2: Artistic interest has a positive impact on personal interest.
H3: Technical interest has a positive impact on personal interest.

2.3 Relationship

Peer relationship in game-based learning includes three parts: collaborative task, peer support and common goal. De Vreede & Briggs (2005) expanded intra-group and inter-group communication through Computer-supported Cooperative Work (CSCW) to achieve an appropriate match between collaboration and task requirements. Mead et al. (2001) stated that peer collaboration enables individuals to achieve the capacity for personal, relational, and social change in learning communities. Brown et al. (1986) pointed out that learners with common goals are willing to exchange professional knowledge and learn from each other, and personal contributions as well as shared beliefs and values will be regarded as supporting factors. Based on the above discussion, H4, H5 and H6 are proposed in this study:

H4: Collaborative tasks have a positive impact on peer relationships.
H5: Peer support has a positive impact on peer relationships.
H6: Common goals have a positive impact on peer relationship.

2.4 Opportunity

Learning opportunities in game-based learning include three parts: weekly game-based learning time, game-based learning frequency, and game-based learning cost. Learning time and learning times per week can effectively reflect the learning frequency of learners. When learners are exposed to game-based learning more frequently, learning opportunities will increase. Lam et al. (2011) pointed out that more frequent learning opportunities can improve task performance in learning. Becker (2000) pointed out that families with high socioeconomic levels have more opportunities to use computers and the Internet at home. Evans & Kantrowitz (2002) pointed out that families with low socioeconomic levels are less likely to use these facilities for game-based learning. Based on the above discussion, H7, H8 and H9 are proposed in this study:

H7: Perceived game-based learning time has a positive impact on learning opportunities.
H8: Perceived gamification learning frequency has a positive impact on learning opportunities. H9: Perceived game-based learning costs have a positive impact on learning opportunities.

2.5 Self-efficacy

Tierney & Farmer (2011) pointed out that the increase of learners' self-efficacy can improve learners' creative performance. Meanwhile, Tierney & Farmer (2002) pointed out that self-efficacy can predict creative performance in addition to learning efficacy. Jaussi et al. (2007) believes that personal identity, self-efficacy and experience play a cross role in learning creativity. Haase et al. (2018) pointed out that the relationship between measures of self-efficacy and creativity depends on the type of measure used, especially between self-report scales and more objective testing procedures. Therefore, based on the above discussion, H13 is proposed in this study:

H13: Self-efficacy has a positive impact on the improvement of game-based learning creativity. To sum up, the research architecture proposed in this study is shown in Figure 1.

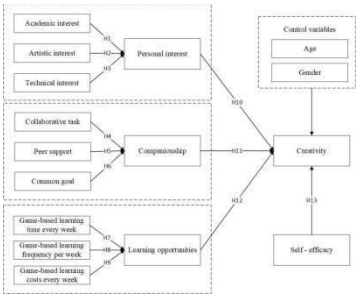

Figure 1. Study Architecture Diagram

3. Methods

3.1 Questionnaire Design

The question design of this study was mainly modified with reference to existing questionnaires in Laakso et al. (2021), Shute & Wang (2016) and Schmidt et al. (2009). The questionnaire included 5 personal interests (e.g. I can use Word, Excal, PPT and other learning software), 5 peer relationships (e.g. Everyone is trying to achieve the same goal in game-based learning) and 5 learning opportunities (e.g. My financial condition can support game-based learning). A 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree) was used to indicate how much the respondent agreed with the item.Before issuing the formal questionnaire, this study conducted a pilot test on the content of the questionnaire, and 16 people participated in the pilot test. The reliability analysis of the indicators in the questionnaire showed that the Cronbach α value of all indicators was greater than 0.7, so the formal questionnaire was issued.

3.2 Data Collection

This research within the scope of Z province colleges and universities in 2022 through the questionnaire system, for open gaming learning questionnaire investigation of the colleges and universities. In terms of questionnaire recovery, a total of 68 questionnaires were collected through the Questionnaire system (WJX), and 12 invalid answers from the unified login account that took less than 30 seconds to fill were deleted, resulting in a total of 56 valid questionnaires and finally 56 valid questionnaires, which were used for formal data analysis. The basic information of the research object is shown in Table 1 below.

Table 1. Basic Information of the Research Object

Project	Group	Quantity	Proportion
Gender	Male	31	55.36%
	Female	25	44.64%
Learning stage	Primary school	8	14.29%
	Junior high school	13	23.21%
	High school	11	19.64%
	University	24	42.86%
Game-based learning frequency per week	high	13	23.21%
	middle	30	53.57%
	low	12	21.43%
Game-based learning time every week	high	9	16.07%
	middle	29	51.79%
	low	18	32.14%

Learning frequency: more than 7 times per week is the high learning frequency, 3-7 times is the middle learning frequency, less than 3 times is the low learning frequency; Learning time: more than 21 hours per week is the high learning time, 7-21 hours is the middle learning time, less than 7 hours is the low learning time.

4. Results

4.1 Reliability Test

Cronbach's Alpha and combined reliability were used to assess the internal consistency of the variables. As shown in Table 2, Cronbach's Alpha of all variables was between 0.73 and 0.94, exceeding the threshold of 0.70 (Nunnally, 1978). The combined reliability of all variables was between 0.76 and 1.00, which exceeded the acceptable value of 0.70 (Fornell & Larcker, 1981). Therefore, the study variables have certain reliability.

Table 2. *Reliability and Validity Analysis Results - Compound Reliability, Cronbach Coefficient and Mean Draw Variation*

	Cronbach's Alpha	**rho_A**	**CR**	**AVE**
Academic interest	0.93	0.89	0.91	0.90
Artistic interest	0.86	0.88	0.91	0.97
Technical interest	0.85	0.75	0.76	0.74
Collaborative task	0.94	0.75	0.75	0.97
Peer support	0.79	0.80	0.80	1.00
Common goal	0.73	0.72	1.00	1,00
Learning time	0.84	0.89	0.74	0.74
Learning frequency	0.89	0.81	0.95	0.73
Learning cost	0.96	0.89	0.77	0.76
Personal interest	0.84	0.75	0.94	0.97
Companionship	0.86	0.77	0.95	0.92
Learning opportunities	0.82	0.92	0.85	0.80
Self - efficacy	0.94	0.79	1.00	0.97
Creativity	0.88	0.80	0.84	0.73

4.2 Validity Test

The purpose of discriminant validity is to test the discrimination degree of measured variables between different constructs. Fornell-larcker method and Heterotrait Monotrait method were used to test the validity of the study (Fornell & Larcker, 1981). The results are shown in Table 3 and Table 4. As can be seen from Table 3, the square root value of the average extracted variance value is greater than the correlation coefficient between constructs, indicating that the results of each construct have discriminant validity. As can be seen from Table 4, the highest HTMT value is 0.94, which is within the acceptable range, and the student sample meets all the standards. Therefore, the results of each construct have discriminant validity.

Table 3. *Fornell-larcker Method*

	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**m**	**n**
a	1.00													
b	0.58	1.00												
c	0.65	0.58	1.00											
d	0.72	0.73	0.74	1.00										
e	0.36	0.70	0.45	0.55	1.00									
f	0.50	0.57	0.69	0.75	0.46	1.00								
g	0.64	0.60	0.84	0.70	0.38	0.61	1.00							
h	0.32	0.41	0.39	0.36	0.50	0.24	0.44	1.00						
i	0.51	0.34	0.51	0.47	0.21	0.46	0.60	0.20	1.00					
j	0.28	0.17	0.39	0.25	-0.02	0.31	0.34	0.11	0.32	1.00				
k	0.64	0.44	0.55	0.48	0.20	0.54	0.54	0.03	0.46	0.46	1.00			
l	0.60	0.65	0.87	0.77	0.44	0.68	0.75	0.30	0.59	0.33	0.55	1.00		
m	0.12	0.07	0.23	0.13	-0.04	0.13	0.28	-0.14	0.39	0.44	0.28	0.31	1.00	
n	0.53	0.39	0.46	0.47			0.16	0.55	0.55	0.00	0.50	0.39	0.91	0.48	0.316	1.00

A. Personal interest; B. Common goal; C. Creativity; D. Collaborative task; E. Companionship; F. Peer support; G. Learning opportunities; H. Academic interest; I. Learning cost; J. Technical interest; K. Learning time; L. Self-efficacy; M. Artistic interest; N. Learning frequency.

Table 4. *Heterotrait-monotrait Method*

	a	b	c	d	e	f	g	h	i	j	k	l	m	n
a														
b	0.58													
c	0.65	0.58												
d	0.72	0.73	0.74											
e	0.36	0.70	0.45	0.55										
f	0.50	0.57	0.69	0.75	0.46									
g	0.64	0.60	0.84	0.70	0.38	0.61								
h	0.32	0.41	0.39	0.36	0.50	0.24	0.44							
i	0.51	0.34	0.51	0.47	0.21	0.46	0.60	0.20						
j	0.28	0.17	0.39	0.25	0.02	0.31	0.34	0.11	0.32					
k	0.64	0.44	0.55	0.48	0.20	0.54	0.54	0.03	0.46	0.46				
l	0.60	0.65	0.87	0.77	0.44	0.68	0.75	0.30	0.59	0.33	0.55			
m	0.12	0.07	0.23	0.13	0.04	0.13	0.28	0.14	0.39	0.44	0.28	0.31		
n	0.53	0.39	0.46	0.47	0.16	0.55	0.55	0.00	0.50	0.39	0.91	0.48	0.32	

A. Personal interest; B. Common goal; C. Creativity; D. Collaborative task; E. Companionship; F. Peer support; G. Learning opportunities; H. Academic interest; I. Learning cost; J. Technical interest; K. Learning time; L. Self-efficacy; M. Artistic interest; N. Learning frequency.

4.3 Structural Model

In this study, Bootstrapping was used to evaluate the PLS results, and 5,000 re-sampling was used as the sampling method (Freedman, 1981). The analysis results of the structural model are shown in FIG. 2. In terms of the explanatory power among individual constructs, the R2 of creativity is 83%. Based on such results, it can be predicted that this study is a model with good explanatory power.

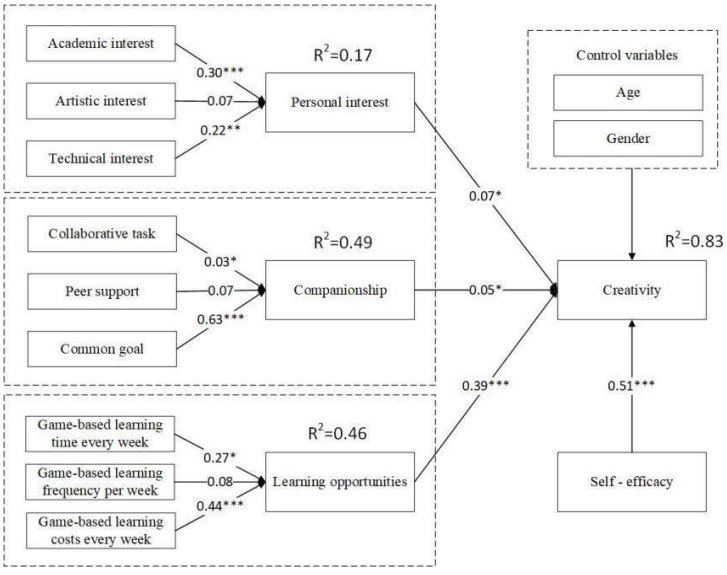

Figure 2. Research Results

According to the structural model analysis results in Table 5, R^2 value is used to measure the prediction ability in the sample. F^2 determines the change of R^2 value when the specified exogenous structure is omitted in the model, and the range is 0.02, 0.15 and 0.35, representing the small, medium or large effect of exogenous structure respectively (Hair et al.,2016). Therefore, F^2 in this study indicates that the structural model has moderate predictive power.

Table 5. *Summary of Structural Model Analysis*

Hypothesis	Project	Path Coefficient	T	P	F^2	Result
H1	Academic interest -> Personal interest	0.30	3.03	0.00	0.10	Support
H2	Artistic interest -> Personal interest	0.07	0.47	0.64	0.00	Nonsupport
H3	Technical interest -> Personal interest	0.22	1.18	0.00	0.04	Support
H4	Collaborative task -> Companionship	0.03	0.15	0.04	0.00	Support
H5	Peer support -> Companionship	0.07	0.51	0.61	0.01	Nonsupport
H6	Common goal -> Companionship	0.63	3.34	0.00	0.37	Support
H7	Learning time -> Learning opportunities	0.27	0.80	0.06	0.02	Support
H8	Learning frequency -> Learning opportunities	0.44	0.23	0.82	0.00	Nonsupport
H9	Learning cost -> Learning opportunities	0.08	3.30	0.00	0.27	Support
H10	Personal interest -> Creativity	0.07	0.75	0.03	0.02	Support
H11	Companionship -> Creativity	0.05	0.63	0.02	0.01	Support
H12	Learning opportunities -> Creativity	0.39	2.66	0.00	0.35	Support
H13	Self - efficacy -> Creativity	0.51	4.07	0.00	0.60	Support

5. Discussion

5.1 Personal Interest and Creativity

It is found that academic interest and technical interest have significant positive influence on personal interest, while artistic interest has positive but insignificant influence on personal interest. Lee (2019) pointed out that art is not easy to be perceived in game-based learning, and knowledge and skills are the main training objectives of teacher educators in game-based learning, and teachers tend to ignore the role of art in the classroom (Shah & Foster, 2015). Game-based learning provides a productive environment for themed learning units, learning computational skills, and improving creativity (Riikonen et al., 2020). In addition, personal interest plays a significant positive role in students' creativity, which is consistent with previous studies. Ford (1996) pointed out that creative and habitual behaviors represent the behavioral orientation of learners' personal interests and competing behavioral choices. Boldt & Paul (2010) pointed out that the creation process of game-based learning can attract students, help students to have better insight and introspection, and promote students' external sharing.

5.2 Companionship and Creativity

In this study, collaborative tasks, peer support and common goals are conducive to the formation of good peer relationships, but peer support has no significant effect on peer relationships. The reason may be that there is still less group cooperation in the process of game-based learning (Pek & Koh, 2021), and more learners tend to

choose independent modules to complete tasks according to their own learning conditions, rather than contact with deeper peer relationships. In addition, peer relationship will promote learners to form better creativity in game-based learning. Sousa & Rocha's (2019) research shows that game-based learning will promote students to form good learning motivation and learning mentality, thus changing the communication mode in group cooperation, and forming a good virtual learning community atmosphere (Spoor & Kelly, 2004).

5.3 Learning Opportunities and Creativity

In this study, both learning time and learning cost have significant positive effects on learning opportunities, while learning frequency has insignificant positive effects on learning opportunities. Previous studies have found that teenagers tend to strengthen their creative self-concept in class (Karwowski, 2015), which in certain circumstances will lead to higher creative benefits for the learning time and cost invested. At the same time, we found that students with high learning frequency tend to use fragmented time to learn (Lenz & Nobis, 2007), and the total amount of time per week is much lower than those with less frequency, so the improvement of creativity is not significant. In addition, learning opportunities have a significant positive effect on the improvement of students' creativity. Burleson (2005) believes that learning opportunities contribute to the self-realization of creativity and learning experience. Glaveanu at al. (2020) pointed out that learning opportunities can help learners to learn knowledge more deeply, thus improving creativity and achieving self-achievement.

5.4 Self - efficacy and Creativity

It is found that self-efficacy plays a significant positive role in improving students' creativity. This is in line with previous studies. Aji et al. (2019) found through empirical research that self-efficacy, creativity and motivation have a very strong relationship with significant interest. Spoor & Kelly (2004) believes that group emotion can provide information about the environment and group members to other group members, so as to coordinate group activities through communication functions. In addition, in gamification learning, group common emotion can coordinate group activities through group bonds and group loyalty, thus generating stronger self-efficacy. When learners have a sense of self-efficacy, they will be better engaged in learning and produce more significant creativity.

6. Conclusion

Research has shown that connected learning is enhanced through the creative use of digital technologies by engaging students in game-based learning.

6.1 Research Significance

This study has certain research significance. Firstly, teachers should introduce the concept of art into game-based learning, cultivate students' artistic perception and appreciation (Brady, 1998), and creatively use digital technology to enhance interconnected learning (Gee & Hayes, 2011). Secondly, teachers should integrate group collaboration into game-based learning to promote the same common goals among learners. Successful game-based learning design requires effective teaching methods to organize collaborative teaching process (Lahti et al., 2004), in which teacher guidance plays a significant role (Øygardslia, 2018). Thirdly, schools and society should provide students with better environmental support and more learning opportunities (Monsen at al., 2014), so as to help students with poor economic conditions to have more connected learning experiences on campus and off campus. Finally, students are encouraged to participate in constructivism interconnected learning (Kafai & Burke, 2015), play a game learning maximum value, and help students have more interest in learning, concentration, the formation of self-efficacy, through the establishment of contact information environment more deeply involved in the Internet learning, help students achieve learning effective contact inside and outside class.

6.2 Research Limitations and Future Prospects

This study has some limitations that need to be addressed in future studies. First of all, the sample size of the study was very small, only 56 students completed the questionnaire, and less than half of the students had high weekly study time and high weekly study frequency. Therefore, the sample could not provide generalizable results for the broader population, and the collection scope of the research questionnaire should be expanded in the future. Secondly, the questionnaire survey is conducted in the class. Although there are researchers in charge of supervision, some learners may peek at the questionnaires of other learners and modify their own questionnaires. Therefore, the research results are easily affected by the cognitive bias of the surrounding environment, resulting in herd mentality. Finally, the factors that influence students' creativity in game-based learning need to be thoroughly investigated in the future, such as the role of learners in game-based learning and the degree of interaction in game-based learning. In addition, when conducting similar surveys, it is better to interview students and teachers to supplement the questionnaire data and provide appropriate basis for research and discussion.

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