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Exploring Effects of Intrinsic Motivation and Prior Knowledge on Student Achievements in Game-based Learning

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***Abstract*:** This study investigates the effects of students' intrinsic motivation and prior knowledge on student achievement in learning Chinese in a game-based learning environment. A total of 140 fourth-grade students from an elementary school in South Korea participated in this study. An instructional game called "Hanjamaru," which is designed to teach Chinese characters, was implemented for four weeks. During the experiment, students' prior knowledge, intrinsic motivation in gaming, and achievements learning Chinese were quantitatively measured. Findings from this study demonstrate that both students' prior knowledge and intrinsic motivation affect their achievements in learning Chinese. Also, there students' prior knowledge and intrinsic motivation affected each other; that is, a group low in intrinsic motivation but with higher prior knowledge showed comparatively higher student achievements. These findings suggest that students' prior knowledge should also be considered while designing and adopting game-based learning in order to engage students with different levels of intrinsic motivation.

Keywords: Game-Based Learning, Instructional Game, Intrinsic Motivation, Prior Knowledge, Student Achievement

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Introduction

With the popularity of games, more educators and teachers are paying attention to instructional games, and starting to use games in classroom teaching and learning. Many research findings revealed that games can be used as an effective tool to support classroom teaching and student learning. The effect of games has been verified in various research studies. One of the effects is that games can enhance students' intrinsic motivation[1][2][3][4].

Motivation has always been a central issue in psychology, education, business, and various other fields. In education, students motivation to learn plays a key role in determining learning outcome; especially, intrinsic motivation is more important than extrinsic motivation in learning. A learner who has a higher degree of intrinsic motivation will achieve more [5][6][7][8][9][10]. Intrinsic motivation and student achievement are positively related.

If instructional games can arouse learners' intrinsic motivation, then we can expect that student achievement can be improved through playing instructional games. There are previous research findings about the effects of instructional games on student motivation and on student achievement. There was a study that examined the relationship between student motivation and learning achievement in game-based learning. However, no research has been conducted focusing specifically on the relationship between intrinsic motivation and learning achievement in game-based learning. Also, no research has been conducted concerning both prior knowledge and intrinsic motivation, and their effects on student achievement. Prior knowledge is also an important element that can influence learning outcomes. Accordingly, the purpose of this study is to examine the effects of students' intrinsic motivation and prior knowledge on student achievement in learning Chinese in an instructional game environment.

Does game-based learning improve student intrinsic motivation and student achievement?

In this section, research about the effects of game-based learning will be reviewed, focusing on intrinsic motivation and student achievement. There is enough evidence to prove the effects of game-based learning on intrinsic motivation and student achievement.

Games are an engaging medium for today's children, because of their elements of fun, rules, feedback, winning, role-playing, challenge, fantasy, curiosity, control, cooperation, competition, recognition, and so on. For these reasons, much attention has been put towards implementing educational games that combine learning content and engaging elements of games. It thus builds an expectation that learning can be fun and engaging like gaming. The implementation of educational games will supplement the weakness of traditional instruction, which can be boring and demotivating. The motivating factors of educational games arouse learners' curiosity, sense of challenge, and fantasy, causing them to be spontaneously immersed in learning while playing. This can provide learners with a break from the repetitive use of boring instructional media[11]. Also, the integration of textbook knowledge and games are helpful for the retention of knowledge in long-term memory[11].

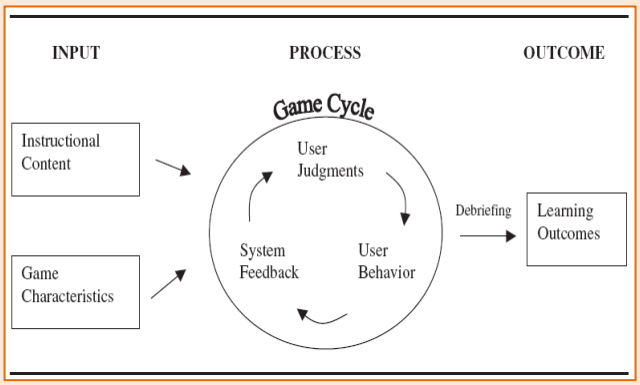

Figure 1. Input-Process-Outcome game model [12]

A tacit model of games and learning depicts the process of learning in a game-based learning environment[12]. According to this game model, the objective of game-based learning is to integrate instructional content and game

characteristics effectively. After instructional content is presented in the form of a game, the game cycle starts. It requires user judgment and user behavior, such as feeling interested and wanting to play. After that, system feedback is given to users. Again, users will respond to system feedback. This is a cycle. When the game cycle ends, debriefing is needed, which will allow for the knowledge and experiences acquired inside the game to be successfully transferred to real life situations. After a serious debriefing is performed, user engagement in game play can result in achieving the intended learning outcome, as an output of game-based learning.

Prior empirical research on educational games implemented in the school has examined the effects of educational games on student achievement and intrinsic motivation to learn. Research findings reveal that game-based learning can be utilized as an effective method for enhancing the intrinsic motivation to learn.

[13] utilized an instructional computer game to teach mathematical and problem-solving skills. This game was designed by applying strategies to enhance a learner's intrinsic motivation. After the intervention, students showed a higher level of intrinsic motivation, and became more deeply involved in learning activities. They also tried to use more complex operations, and thereby learned more in a fixed time period.

An instructional game especially designed for learning computer memory concepts was implemented in a computer science class of high school students to test the learning effectiveness and motivational appeal of a computer game[14]. The game was designed according to a Greek high school curriculum for computer science. The participants of this study were randomly assigned to two groups: one group was taught in the form of web-based instruction, while another group was taught using game-based learning. After the experiment, the degree of knowledge acquisition by students about computer memory concepts was evaluated. The findings of this study demonstrate that a statistically significant difference was observed between the two groups. The students who received game-based learning outperformed the students who received web-based instruction in both the motivation to learn and the degree of knowledge acquisition of computer memory concepts.

A study exploring the effectiveness of MMORPG-based instruction in elementary English education was undertaken[15]. A Korean educational game named "Nori School" (nori means 'play' in Korean) was utilized to teach English. To verify the effectiveness of game-based instruction, the results of learning were compared to a control group who learned in a traditional face-to-face environment. The results indicate that students who received game-based instruction gained higher scores in the areas of listening, reading, and writing than those who received traditional instruction. Motivation to learn, prior knowledge, and network speed were proven to be the factors affecting student achievements. There are other studies reporting the positive effects of gaming[16][17][18].

■ Does intrinsic motivation impact student achievement?

The correlation between intrinsic motivation and student achievement has been verified. Many research findings demonstrate that intrinsic motivation positively correlates with student achievement[5][6][7][8].

In a study conducted by [8], college students' extrinsic and intrinsic goal orientations were tested. Findings show that the level of intrinsic motivation positively related to grades. Students who have higher intrinsic motivation obtained better achievement scores compared to students who have higher or lower extrinsic motivation. [7] examined the relationship of intrinsic motivation and grades to standardized test scores. The participants were children from 3rd to 8th grade. Research findings revealed that children's motivations positively correlate with children's grades and standardized test scores at all grades. [10] reported the same result on student's reading performance. Also, [19] reported a positive correlation between intrinsic motivation and chemistry concepts.

As described above, intrinsic motivation can be seen as a strong predictor of student achievement. In order to help make learners practice self-direction and keep them deeply involved in learning, and to improve student achievement, providing intrinsically motivating environments for learners seems significantly important.

■ Does prior knowledge impact student achievement?

Knowledge acquisition occurs when students' prior knowledge and new information are connected, though the prior knowledge of each student is different. Different levels of prior knowledge will lead to different levels of achievement. Prior knowledge is an important variable affecting student achievement. Several studies were conducted on the impact of prior knowledge in a game-based learning environment.

In the study of [15] which investigated the effectiveness of MMORPG-based instruction in elementary English teaching, prior knowledge was addressed as one of the factors affecting student achievement, as described in the previous section. [18] examined the effects of prior knowledge on student motivation and achievement in mathematics, in the context of a game-based learning environment. The quantitative data collected from students revealed that prior knowledge did not impact motivation and achievement. However, interviews with teachers revealed that most teachers insisted that a student's level of prior knowledge plays a significant role in playing games. [20] examined the effects of prior knowledge on solving mathematical problems in a computer game environment. According to the level of their prior knowledge, participants were assigned to two groups: a high level group and a low level group. As a result, the group with high prior knowledge showed better performance in solving mathematical problems when compared to the group with low prior knowledge. [21] also verified the importance of prior knowledge. Their research findings showed that students with high prior knowledge acquired higher comprehension scores, higher learning efficiencies, and less cognitive loads in high-interactive computer simulations, compared to low-interactive simulations. In contrast, students with low prior knowledge benefited more from low-interactive simulations.

According to the studies mentioned above, prior knowledge of a student can be seen as a strong predictor of student achievement in game-based learning. In order to improve a learner's academic achievements, consideration of their prior knowledge level can make a difference in game-based learning.

Research methods

The purpose of this research is to examine the effect of student intrinsic motivation and prior knowledge of student ability in learning Chinese in a game-based learning environment. An instructional game named "Hanjamaru" was used in this study. The student's prior knowledge was tested before the experiment. Tests for intrinsic motivation and student's achievement in learning Chinese were administered after the experiment.

Research questions

- Does a student's intrinsic motivation in gaming have a positive effect on student achievements in learning Chinese in a game-based learning environment?
- Does a student's prior knowledge have a positive effect on student achievements in learning Chinese in a game-based learning environment?

Participants

The participants of this study were 140 elementary school students in Grade 4 from South Korea. The participants consisted of 81 boys and 75 girls. Their ages ranged from 9 to 10 years. They all had basic computer skills to play the game. In order to prevent students' prior gaming experience from affecting the result of this study, students with no prior experience about the game "Hanjamaru" were selected as participants. Therefore, the final sample of this study was reduced to 140 students.

Game

"Hanjamaru" is a game designed for teaching Chinese characters to Korean children. It was developed by "Eduflo," which specializes in developing educational games in South Korea. A company named "Nowcom" is now providing the service. "Hanjamaru" is a 2D side-scrolling Role-Playing Game (RPG) where players can easily move their characters on a 2D screen. As shown in the following screen captures, Chinese characters are cast on the body of the monsters. When players attack monsters in the dungeon, they acquire experience points, and in time players master skills and advance in levels. Also, character boards containing the characters they have learned are provided as a reward. When learners hit the monster, the pronunciation and meaning of that character can be heard repeatedly by learners. So, learners receive both visual and audio stimuli.

In addition, there are activities designed for students to reflect on what they have learned. Whenever learners advance to the next dungeon, they are made to do a quiz to test if they mastered the content in that dungeon. They can also use the character boards to create new characters by combining two different characters. Because of the characteristics of Chinese characters, it is possible to combine two characters into a new one. Moreover, during the game, consistent guidance is provided by Non-Player Characters (NPCs) embedded in the game, urging the learners to perform quests and giving positive feedback for encouragement.

Figure 2. Screen captures of "Hanjamaru."

■ Instruments

Test of intrinsic motivation

The test to measure Intrinsic Motivation was developed by the author of this study based on [1], and Malone (1981)'s taxonomy of intrinsic motivation. They identified the reason behind why gamers are so engaged and motivated to play games, and presented variables associated with intrinsic motivation. The context of their research was the gaming environment, similar to this study. However, there is no questionnaire designed to measure intrinsic motivation based on [1] or Malone's (1981) taxonomy of intrinsic motivation. Also, there is no questionnaire designed to measure intrinsic motivation in gaming. Therefore, it was essential to develop a questionnaire to test intrinsic motivation in gaming that is based on the taxonomy of intrinsic motivation. The individual intrinsic motivation scale of [1] and Malone (1981) consists of four subscales: challenge, curiosity, control, and fantasy. Each subscale was made up of four items. Thus, the whole test consisted of 16 items. The five-point Likert scale ranged from "strongly disagree" to "strongly agree." The total score of the intrinsic motivation test was 80. The validity of the content of the developed scale was reviewed by a professor of Educational Technology and two experienced elementary school teachers. The Cronbach α of the test is 0.90. Each item was made in accordance with the heuristics for designing an intrinsically motivating instructional environment as advocated by [1]. More detailed information about the four variables is in the second part of this paper.

Table 1. Heuristics for designing intrinsically motivating instructional environment

Challenge	Goals Uncertain outcomes Performance feedback Self-esteem
Curiosity	Sensory curiosity Cognitive curiosity
Control	Contingency Choice Power
Fantasy	Emotional aspects Cognitive aspects Endogeneity

Test of Prior knowledge

To prevent learners' prior knowledge of Chinese characters from affect the result of this study, a test to assess learners' prior knowledge was administered before the experiment. The test consisted of fifty Chinese characters. The test was developed by the author of this study in accordance with the Practical Old Chinese Character Level Test in Korea, by the Korean Foreign Language Evaluation Institute. The total score of the test is 50.

Test for student achievement in learning Chinese

Test for student achievement in learning Chinese was made by the researcher of this study. The contents of this test are the characters used in the game. This test consists of two parts: the first part examines the pronunciation of the characters, and the second part examines both the pronunciation and meaning of the characters. In all, fifty characters are included. The total score of the test is 50.

■ Procedure

The game "Hanjamaru" was implemented for teaching Chinese characters to fourth graders over four weeks, two hours a day, twice a week. In total, students played for 16 hours. Lessons were taken in a computer room. During the four weeks of implementation, students were not allowed to play the game except during experimentation time. The selected teachers were experienced teachers familiar with using technology, and the game.

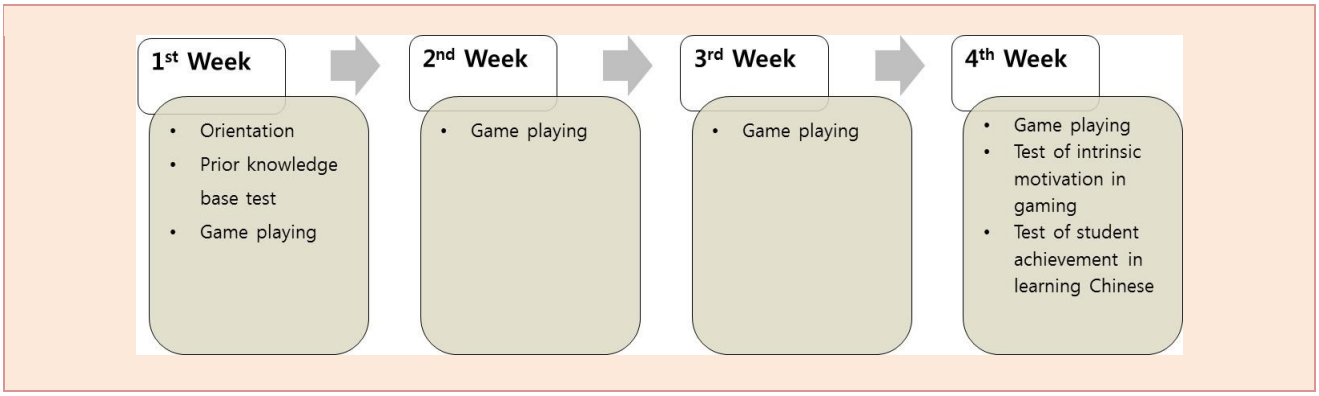

Figure 3. Procedure of implementation.

- Activity of the 1st Week: Orientation, test to assess prior knowledge, and game

In the first week, a test to assess student knowledge about Chinese characters was run. The test was paper-based. After the test, teachers guided and supported learners to sign up for a membership on the portal website of the game "Hanjamaru." Also, the teachers asked learners to download the game from the website. Teachers informed learners about the goal of the game, and the basics like starting the game, how to log in, how to manipulate the interface, how to create characters, etc. After, learners played the game on their own by following the tutorial provided inside the game.

- Activity of the 2nd week: Playing Game

In the second week, learners continued to play the game in the computer room. Whenever learners encountered technical problems, the teacher provided help.

- Activity of the 3rd week: Playing Game

In the third week learners continued to play the game for a fixed time.

- Activity of the 4th week: Playing Game, test of intrinsic motivation in gaming, the test of student achievement in learning Chinese

In the fourth week of implementation, learners also played games for two hours per day, two days per week. On the last day, after two hours of game playing, a test to assess intrinsic motivations and another to assess student achievements in learning Chinese were distributed to test the effects of four week implementation. Both of the two tests were paper-based.

Data Analysis and Results

A two-way ANOVA was conducted in order to examine the effects of intrinsic motivation and prior knowledge on student achievement. The descriptive table is presented below:

Table 2. Descriptive statistics

Intrinsic Motivation	Prior knowledge	Mean	Std. Deviation	N
High	High	42.43	6.739	37
	Low	29.12	7.066	33
	Total	36.16	9.573	70
Low	High	38.31	6.646	35
	Low	20.11	7.572	35
	Total	29.21	11.577	70
Total	High	40.43	6.962	72
	Low	24.49	8.574	68
	Total	32.69	11.143	140

According to Table 2, the mean of student achievement for the group with high prior knowledge is 40.43, while that of the low group is 24.49. The mean of student achievement for the group with high intrinsic motivation is 36.16, while that of the low group is 29.21.

Table 3 below is Levene's Test of Equality of Error Variance.

Table 3. Levene's Test of Equality of Error Variance[a]

F	df1	df2	Sig.
.434	3	136	.729

a. design: Intercept + Prior knowledge + Intrinsic Motivation + Prior Knowledge * Intrinsic Motivation

Table 3 tests the null hypothesis that the error variance of the dependent variable is equal across groups. From Table 3, we can see that we have homogeneity of variance of student achievement across the groups. This is true when the significance value is greater than .05, which is the level we set for alpha.

Dependent Variable: Student achievement

a. R Squared = .613 (Adjusted R Squared = .604)

Table 4 shows a statistically significant interaction between prior knowledge and intrinsic motivation and its effect on student achievement (F=4.248, p=.041). There is a significant difference in the statistics of student achievement between groups with high and the low prior knowledge (F=176.502, p=.000). The effect size of prior knowledge is 0.6. According to Cohen (1988), this is a medium-level effect. In addition, there is a significant difference in statistics between groups with high and low intrinsic motivation (F=30.621, p=.000). The effect of intrinsic motivation is 0.2, which means the effect is small.

Figure 4 illustrates a plot with a good graphical illustration of the result. We can get an idea of whether there is any effect of interaction by inspecting whether or not the lines are parallel.

From Figure 4, we can see how results from Table 2 and Table 4 might make sense. The interaction between prior knowledge and the intrinsic motivation is not strong, but it is implied by trends.

To sum it up, a two-way ANOVA was conducted that examined the effects of prior knowledge and intrinsic motivation on student achievement. The dependent variable, student achievement, was normally distributed for the groups formed by combining the levels of prior knowledge and intrinsic motivation as assessed by the Shapiro-Wilk test. There was homogeneity of variance between groups as assessed by Levene's test for equality of error variances. There was a significant interaction between the effects of prior knowledge and intrinsic motivation on student achievement. A simple main effect analysis showed that there was a significant difference in the statistics of student achievement between groups

with high prior knowledge and low prior knowledge. In addition, there was a significant difference in statistics between groups with high intrinsic motivation and the low intrinsic motivation.

Table 4. Tests of between-subject effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	10574.489[a]	3	3524.830	71.723	.000
Intercept	147592.787	1	147592.787	3003.228	.000
Intrinsic Motivation	1504.876	1	1504.876	30.621	.000
Prior knowledge	8674.166	1	8764.166	176.502	.000
Intrinsic M * Prior KB	208.784	1	208.784	4.248	.041
Error	6683.682	136	49.145		
Total	166828.000	140			
Corrected Total	17258.171	139			

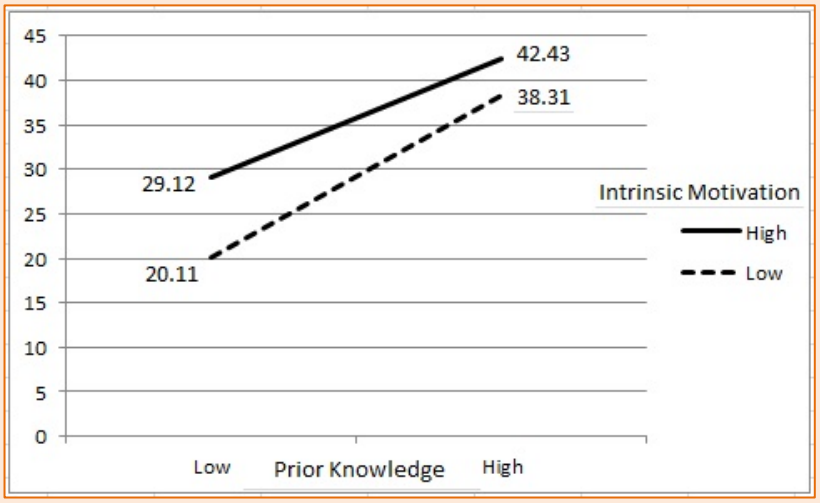

Figure 4. Estimated marginal mean of student achievement

Conclusion

The purpose of this study was to examine the effects of intrinsic motivation and prior knowledge on student achievement in learning Chinese in a game-based learning environment. The findings indicate that both prior player knowledge and intrinsic motivation affect student achievement in the game-based learning environment. Also, the group with low intrinsic motivation and higher prior knowledge showed comparatively higher student achievement.

This result is consistent with prior research on the effects of intrinsic motivation in improving student achievement, as conducted by [5][6][7][8][9][10][19]. In addition, the findings provide evidence to support findings by [15][20], who examined the effects of prior knowledge on learning outcome in a game-based learning. Also, it is consistent with the research conducted by [21] who examined the effects of prior knowledge on learning outcomes in a computer simulation. Although there were studies which investigated the effects of intrinsic motivation or prior knowledge, they were done separately. There was no study that tested the combined effect of both intrinsic motivation and prior knowledge together. Therefore, this study sheds light on the importance of both prior knowledge and intrinsic motivation when designing and adopting instructional games.

Although intrinsic motivation is suggested to be a significant factor that contributes to student achievement, prior knowledge is also a prerequisite for improving student achievement in game-based learning. If learners do not have enough prior knowledge before gaming, there is no significant improvement in their achievement even when they have a high intrinsic motivation while they play. According to the degree of prior knowledge, content with different levels of difficulty should be provided to the learners to maximize effective learning. It is suggested that both intrinsic motivation and prior knowledge should be considered carefully when designing and adopting instructional games for teaching and learning. Further research is needed to consider additional tangible elements which have a positive impact on student achievement in a game-based learning environment.

Nevertheless, there are certain limitations in this study. The time for game implementation was relatively short, because of the restriction in time allowed to use computers at schools. If more time is allowed, the results may have more power to support the conclusion.

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