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Analyses of the Structural Relationships between College Students' Perceived Game Realism, Flow and Learning Satisfaction in Game-Based Learning

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Perceived game realism (PGR) has recently emerged as a key concept in explaining the mental processing of digital game playing and the societal impact of digital games. However, few studies have examined its conceptualization and educational effects from an empirical viewpoint, especially in educational games. This study's participants included 292 university students in South Korea. A total of 212 questionnaires were valid and used for the analyses. They learned English expressions using a computer-based educational game and then completed questionnaires on the research variables. We investigated six factors of PGR: simulational realism (SIR), freedom of choice (FRC), perceptual pervasiveness (PEP), social realism (SOR), authenticity (AUT), and character involvement (CAI). We expected the factors to have valid effects on the university students' flow and learning satisfaction after a game-based learning (GBL) experience. Our research results demonstrated a causal relationship between SIR, FRC, CAI, and learning satisfaction. Furthermore, the indirect effects of SIR and CAI on learning satisfaction through flow were statistically significant.

Keywords : perceived game realism, game-based learning, flow, learning satisfaction

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Introduction

While many games are attractive and interesting, some games are tiresome and boring, even the first time. "Interesting" gameplay largely depends on how well the game's key elements and technologies feed into it. It is equally important that game-based learning reflects those key elements. The various game elements include goals, rules, competition, cooperation, reward system, feedback, and storytelling, all of which help learners experience playful learning, learning by doing, and cooperative learning (Kirriemuir & McFarlane, 2004). Prensky (2001) defined the combination of games' characteristics and educational contents as GBL, allowing learners to use games independently to reach learning goals without teacher involvement.

In recent years, there has been increasing interest in applying serious games to medical care and rehabilitation, and it is postulated that incorporating games can provide a more immersive context and better motivation during practice (Harvey et al., 2021). Using games for training purposes is also gaining popularity in several areas, including military, medicine, surgery, and disaster response (Spiegel, 2018; Vehtari et al., 2019), because virtual reality (VR) games and their technologies can construct outstanding simulated reality, these games extend opportunities from indirect to hands-on experience through educational methods. The game players accept these experiences compared to reality and refer concepts from the games to real examples (Seidel, Bettinger, & Budke, 2020). In particular, the emotions experienced by game players during a VR game have the effect of game immersion (Hwang & Park, 2010). Instead of relying on traditional equipment such as a mouse and keyboard, the interaction between user and virtual environment can accelerate the process of initial learning and familiarization (Schnack, Wright, & Holdershaw, 2019).

In GBL, a learner's flow experience occurs when the game properly combines students' learning abilities with challenges (Sherry, 2004). Flow refers to the state of attraction or concentration in which learners are deeply involved in certain activities (Csikszentmihalyi, 1990). Game flow is an essential factor in the educational effect

(Prensky, 2001). Clarke and Haworth (1994) also argued that games provide learners with an optimal flow experience by guiding them to continue playing games.

Despite the fantastic and unrealistic spatial design of VR games, the gameplay environment for players immersed in the game can feel like reality. This experience is linked to perceived realism, referring to how real the players find the VR game. Perceived realism describes the cognitive processing and media effects on humans from the media's messages. The concept helps analyze viewers' perceptions and emotions toward media such as television, movies, and documentaries (Potter, 1988).

While this research on media has attempted to define perceived realism and its effects, few game-related studies have been conducted. However, the emergence of research in perceived realism in digital games attempts to extend perceived media realism to game studies. Ribbens and Malliet (2010) explored factors of digital game realism based on perceived realism research by Potter (1988) and Shapiro, Peña-Herborn, and Hancock (2006). Based on these prior studies, Ribbens (2013) investigated sub-factors of perceived game realism (PGR) through exploratory analysis as follows: simulational realism (SIR), freedom of choice (FRC), perceptual pervasiveness (PEP), social realism (SOR), authenticity (AUT), and character involvement (CAI).

While there are many studies on the relationship between factors that influence the learners' flow in a GBL environment, few research on the relationship between PGR and learning effectiveness have been conducted. Therefore, revealing this relationship is vital in establishing the basis of PGR—a game's flow factor—and how it can help learners optimize their educational games' flow experience. Our study establishes a research model based on a review of related prior studies to identify the relationship between flow and learning satisfaction with six sub-factors of PGR that affect the GBL environment in educational games. Therefore, we will provide suggestions for developing effective educational games and a teaching design that considers variables in expanding and utilizing VR games as a method for teaching and learning.

Research Background

Game-Based Learning

Game-based learning refers to the natural reach of learners through games. By combining the exciting and immersive elements of a game into learning, GBL delivers a more effective learning and helps learners enjoy learning. Prensky (2001) defined GBL as a combination of educational content and computer games to match or exceed learning achievements compared to traditional methods. Prensky (2001) supports GBL for the following reasons. First, putting learning into game content can bring engagement. Learning occurs naturally through engagement, even if it is a subject that learners do not prefer and tend to avoid. Second, GBL enables interactive learning to take place in different forms according to different learning objectives. This form variety is the most distinguishable feature from existing teacher-oriented learning, which provides a relatively single learning form. Third, it provides multiple solutions that are not set. This flexibility ensures the best solution from the various methods.

Perceived Realism

The study of perceived realism seeks to explain perception of reality that viewers receive from the media. According to Potter (1986), perceived realism is the degree to which the viewer accepts the media content or the degree to which the content and reality are confused and taken similarly to reality. This concept provides a theoretical basis for understanding the viewer's perceptions and emotions, depending on how realistically the user perceives the media's content.

Perceived realism in cultivation theory validates the hypothesis that humans form ideas or concepts about the real world through media (Potter, 1986). Cognitive approaches to cultivation theory focus on viewers' exposure to media messages and how they deal with the media content and the real world. Potter (1992) tried to break down the measurement area of cultivation theory by verifying the perception process and dividing it into three dimensions: magic window, identity, and utility. Based on a study of television programs and viewers' perceived realism, Potter (1992) presented the following conclusions: First, all viewers do not feel the same perceived realism from the program's content. Second, viewers who recognize media content as relatively realistic are more affected than those who do not. Third, the degree to which media reports are perceived to be real is less relevant to demographic factors such as age or gender.

Perceived Game Realism

Simulational realism (SIR) is a characteristic of digital games in which players enable experimental experience through games (Frasca, 2003; Jansz, 2005; Ribbens & Malliet, 2010). According to Ko and Choi (2002), edutainment content motivates learners' through reality and fantasy, allowing them to safely perform war games, investment strategy games, and sports containing rather dangerous elements. Due to simulational realism characteristics, players can experiment with the results of self-determined solutions and actions without physical or psychological barriers when the game tasks resemble real life. Based on these characteristics, learners can realize that those game activities and individual daily activities are not entirely divided. There is a close link between the exercises due to realistic rules programmed in the game.

Freedom of choice (FRC) is the second factor determining the games' reality, highlighting the similarities between the games' choice elements and our real-life options (Ribbens & Malliet, 2010). Suppose that the simulated reality factor is related to rules that the player cannot change by game pre-setting. In that case, the freedom of choice is associated with the player's direct intervention in game activities to create personalized stories. According to Malliet (2006), game players can enjoy considerable freedom by getting opportunity of various selection through the virtual world, and the more these choices reflect the choices they encounter in their daily lives, the more they feel the game realistic.

Graphic realism is also the most frequently emphasized aspect of video game effects research because it best reflects digital game realism (Hall, 2003). Perceptual pervasiveness (PEP) also identifies the intensity of hearing, vision, and touch as a characteristic that contributes to games' overall realism. This logic assumes that the more likely the game is to provide a realistic experience to the player, the more it influences the player's attitudes and behaviors (Ribbens & Malliet, 2010). Hall (2003) and Mallet (2006) define perceptual pervasiveness as the extent to which text causes a compelling visual illusion regardless of how much the content of the text may be related to real-world experience. Such a definition goes beyond the strict concept of graphic realism and refers to the precise representation of real-life movements, facial expressions, locations, and sounds.

Through game rules, players can learn how to behave as valued members of society and apply their learning to reality. This simulation has significant similarities to the 'utility' factor, mainly addressed in perceived media realism. Galloway (2004) defined social realism (SOR) as "a characteristic of a game that critically reflects minor daily events full of struggles, personal narratives, and unfairness." Social realism focused on the unique social characteristics of the game. The games' social aspects can also affect the games' overall realism through social relationships formed within the game.

Authenticity (AUT) is a window into the reality of media and is the oldest concept mentioned in the study of perceived media realism. The factual level of unrealistic objects that media fiction presents contributes to a considerable sense of reality (Ribbens & Malliet, 2010). Shapiro et al. (2006) argued that a typical everyday life element reinforces the fantasy of virtualized reality in digital game stories, allowing game developers to express emotionally persuasive poetic messages. Such digital games' characteristics can give games a realistic or authentic feel to the player, even if the games' main action takes place in a fantasy setting (Ribbens, 2013).

Character involvement (CAI) is a concept describing the experience of acting and controlling avatars in a player's own digital game. Jansz (2005) argued that the main characteristic of the theories related to character involvement is that the player is both an active subject during gameplay and the game's audience. Calleja (2007) defined the experience of reality created in the game as the overall process in which the player identifies the character and plays the character simultaneously. Players experience emotional attachment projecting themselves onto the game avatar to feel the emotions and actions experienced by their characters as their own experiences, and as a result, accept and act as their own (Cohen, 2001; Peng, Lee, & Heeter, 2010).

Major Learning Outcomes in GBL

Flow is an experience that anyone can reach, only different people have different intensities and frequencies (Csikszentmihalyi, 1990). When in a state of flow, concentration, enjoyment, happiness, strength, motivation, and self-esteem increase. The experience of flow is the resource that drives learners to keep learning; the more immersed they are in a particular activity, the more actively involved. The experience of flow is similar in learning through edutainment. Games create an engaging educational environment to increase learners' motivation, allowing them to focus on the game and train naturally, without feeling that they are learning (Roh, Park, & Choi, 2012). Based on the games' characteristics, learners can continue to learn for a more extended period as they feel immersed in their experience through edutainment (Baek, 2005).

Furthermore, educational games aimed at adding fun elements to learning and bringing educational effects, unlike general entertainment games, should allow players to feel the satisfaction associated with learning because of the game. Although the traditional learning environment is concerned with learners' academic performance, new media and teaching methods such as educational games significantly affect the learner's satisfaction and continued learning in the future (Kang, 2006). GBL provides learners with a real or hypothetical opportunity to apply new knowledge or skills successfully. Kapp (2012) said that these GBL features are one of strategies that can motivate learners to understand their new learning more precisely during the learning. Therefore, by measuring learners' satisfaction, instructors can use it as an indicator to determine whether learners' needs have been met or whether learners have achieved successful learning experiences (Kim & Kang, 2010). Summing up these statements, we specify learning outcomes as occurring within gameplay's flow and learning satisfaction.

Research Hypotheses

The previously stated backgrounds and literature review provide the foundation for the following hypotheses:

H1: The factors of perceived game realism—SIR (H11), FRC (H12), PEP (H13), SOR (H14), AUT (H15), and CAI (H16)—affect flow.

H2: The factors of perceived game realism—SIR (H21), FRC (H22), PEP (H23), SOR (H24), AUT (H25), and CAI (H26)—affect learning satisfaction.

H3: The flow affects learning satisfaction.

Methods

Research Design

Figure 1 illustrates our study's model based on prior research and theoretical background. We applied the model to uncover the relationship between PGR, flow, and learning satisfaction for college students in GBL. We developed a general structural model based on the related literature review consisting of exogenous and endogenous variables. The arrows linking the variables specify hypothesized causal relationships in the direction of the arrows. We set the specific hypotheses according to the arrows. The flow outcomes are related to SIR (H11), FRC (H12), PEP (H13), SOR (H14), AUT (H15), and CAI (H16). The learning satisfaction outcomes are related to SIR (H21), FRC (H22), PEP (H23), SOR (H24), AUT (H25), and CAI (H26). Finally, the flow is related to learning satisfaction (H3). The arrows between the latent variables and the observed indicators indicate measurement validity. Appendix describes the indicators for each variable.

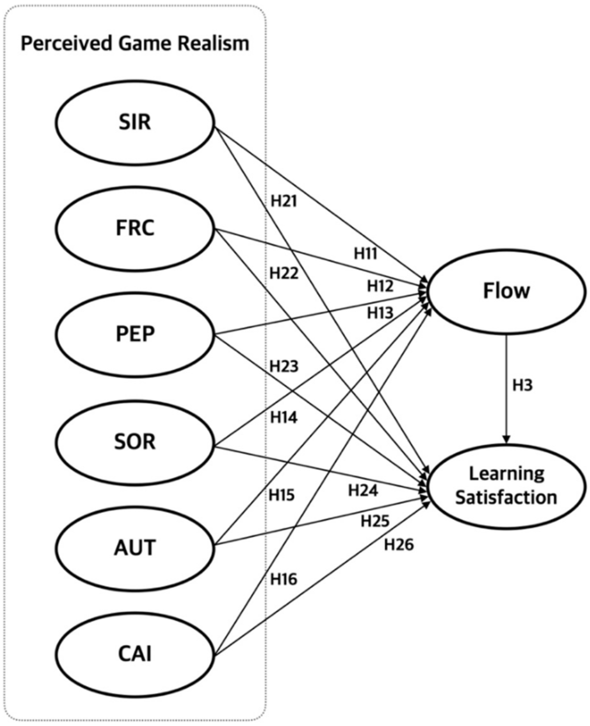

Figure 1. Instrumentation and Statistical Procedures

Participants

In this study, we selected undergraduate students from K University in Seoul, Korea, as research target population for determining the structural relationship between PGR, flow, and learning satisfaction using educational games for GBL. We distributed 292 questionnaires and received 231 completed surveys. Of these, we removed 19 questionnaires containing unreliable and missing responses. We conducted a final analysis of the data of 212 questionnaires. Table 1 includes the gender and grade characteristics of the study participants. The survey found that 112 males (52.8%) and 100 females (47.2%) were relatively evenly distributed, with 174 (82.1%) in first grade, 31 in second grade (14.6%), five in third grade (2.4%), and two in fourth grade (0.9%).

Table 1. Sample Demographic Information

	Subject	Frequency(N)	Percentage (%)
Gender	Male	112	52.8
	Female	100	47.2
Grade	1	174	82.1
	2	31	14.6
	3	5	2.4
	4	2	0.9
Total		212	100

Game Plays

Participants were divided into eight groups of about 40 people and played educational games for 40 minutes. The educational game was played by computer-based environment and it was conducted face-to-face. We controlled the learners' GBL activities to ensure the reliability of measurement results as follows: first, we provided a brief introduction of the game to ensure that participants played the game at the same level; second, we controlled the GBL experience time so that learners could not perform the activities outside of the designated time, observing the same game-learning time.

We chose the educational game software for analyzing this study's hypothesis based on several criteria: online educational games provided in Korean, games offered to adult learners, and games played by students with a relatively balanced proportion in both entertainment and education. Based on these criteria, the researchers selected the "T" game software as a tool for research (see Figure 2).

In the world of "T" game software, the player becomes the main character in the "Live a Year in New York" project, communicating with a non-player character (NPC) in English and solving the game's mission and quest. The players' goal is to raise their level and improve their English conversation skills. The players' challenge is to build their experience depending on mission achievement, allowing learners to earn cyber money in the game. Players use game money to change the avatar's costume. These game activities are related to learners' interactions and communication abilities and are critical to GBL experiences (Huizenga, Admiraal, Dam & Voogt, 2019).

Questionnaires and Data Collection

We wrote and reconstructed the questions for each variable to suit the study's purpose. Two professors in educational technology and one Ph.D. in educational technology verified the questionnaire's face validity. We created PGR-related items based on Ribbens and Malliet (2010). We excluded the validity check from the original questionnaire because, in the process of translating questions into Korean, we found that the interpretations of question 5 of the SIR factor, question 1 of the FRC factor, and question 1 of SOR were the same as question 1 of SIR, question 2 of FRC, and question 4 of SOR. Finally, all six sub-factors consisted of four questions each through the reconstruction.

We developed the flow items based on Killi, Freitas, Arnab, and Lainema (2012), mainly designed for the GBL context. We used the items for learning satisfaction based on Yu , Chang, Liu, and Chan (2002)'s research. We modified their items to fit the study objectives and the Korean college context. Each construct had four items, and we measured all constructs on a 5-point Likert-type scale from 1 (*strongly disagree*) to 5 (*strongly agree*).

Collected data were immediately coded in Microsoft Excel and transferred to the

SPSS 22 for descriptive statistics calculations. We used AMOS for structural equation modeling (SEM).

Figure 2. Screenshot of the “T” game software

Results

Analysis of Measurement Model

Before confirmatory factor analysis, we grouped in threes the questions regarding flow and learning satisfaction using an item parceling method. We used this method because there were too many questions about flow and learning satisfaction for estimating with a confirmatory factor analysis for individual questions. Also, estimating many unknown quantities in limited samples increases the estimation error (Bentler & Chou, 1987; Marsh, 1994). We used a randomized grouping method to ensure evenly distributed question reliability and validity (Moon, 2009). We calculated each question group's average score and used it as a measurement variable in the SEM.

We checked discriminant validity and multicollinearity by examining correlations among the constructs. All correlation coefficients were less than .85, suggesting sufficient discriminant validity and low multicollinearity (David, 2016). Table 2 shows the correlation matrix among the constructs.

Table 2. Correlations Among Constructs

Latent variables		SIR	FRC	PEP	SOR	AUT	CAI	FL	SA
PGR	SIR	1							
	FRC	.315***	1						
	PEP	.334***	.285***	1					
	SOR	.569***	.281***	.538***	1				
	AUT	.543***	.379***	.574***	.693***	1			
	CAI	.478***	.412***	.451***	.552***	.545***	1		
Flow (FL)		.535***	.422***	.489***	.494***	.547***	.563***	1	
Learning Satisfaction (SA)		.535***	.353***	.415***	.532***	.549***	.536***	.736***	1

***$p < .001$

Table 3. Summary

Latent variables		Observed variables	Question number	Mean	SD	Skewness	Kurtosis
PGR	SIR	SIR1	1	3.78	.735	-.501	.283
		SIR2	2	3.79	.768	-.634	.343
		SIR3	3	3.87	.819	-.492	-.114
		SIR4	4	3.83	.791	.385	-.148
	FRC	FRC1	5	3.05	1.113	-.094	-.835
		FRC2	6	3.28	.976	-.100	-.475
		FRC3	7	3.36	.995	-.344	-.346
		FRC4	8	3.33	.994	-.224	-.468
	PEP	PEP1	9	3.27	.993	-.066	-.351
		PEP2	10	3.85	.984	-.695	-.086
		PEP3	11	3.90	.865	-.730	.525
		PEP4	12	3.54	1.027	-.433	-.543
	SOR	SOR1	13	3.54	.883	-.282	-.274
		SOR2	14	3.88	.781	-.383	-.144
		SOR3	15	3.38	.918	-.190	-.310
		SOR4	16	3.69	.776	-.451	.284
	AUT	AUT1	17	3.74	.745	-.222	-.173
		AUT2	18	3.65	.821	-.260	.124
		AUT3	19	3.99	.773	-.544	.458
		AUT4	20	3.87	.736	-.291	-.099
	CAI	CAI1	21	3.27	1.118	-.291	-.819
		CAI2	22	3.10	1.088	.015	-.724
		CAI3	23	2.77	1.078	.348	-.404
		CAI4	24	3.41	.971	-.577	.214
Flow		FL1	4, 6, 7	3.57	.738	-.388	.466
		FL2	1, 5, 9	3.64	.658	-.328	.522
		FL3	2, 3, 8	3.66	.596	-.126	-.404
Learning satisfaction		SA1	1, 2, 5, 10	3.35	.450	-.113	-.237
		SA2	3, 6, 9, 11	3.78	.676	-.178	-.539
		SA3	4, 7, 8, 12	3.26	.460	-.116	-.590

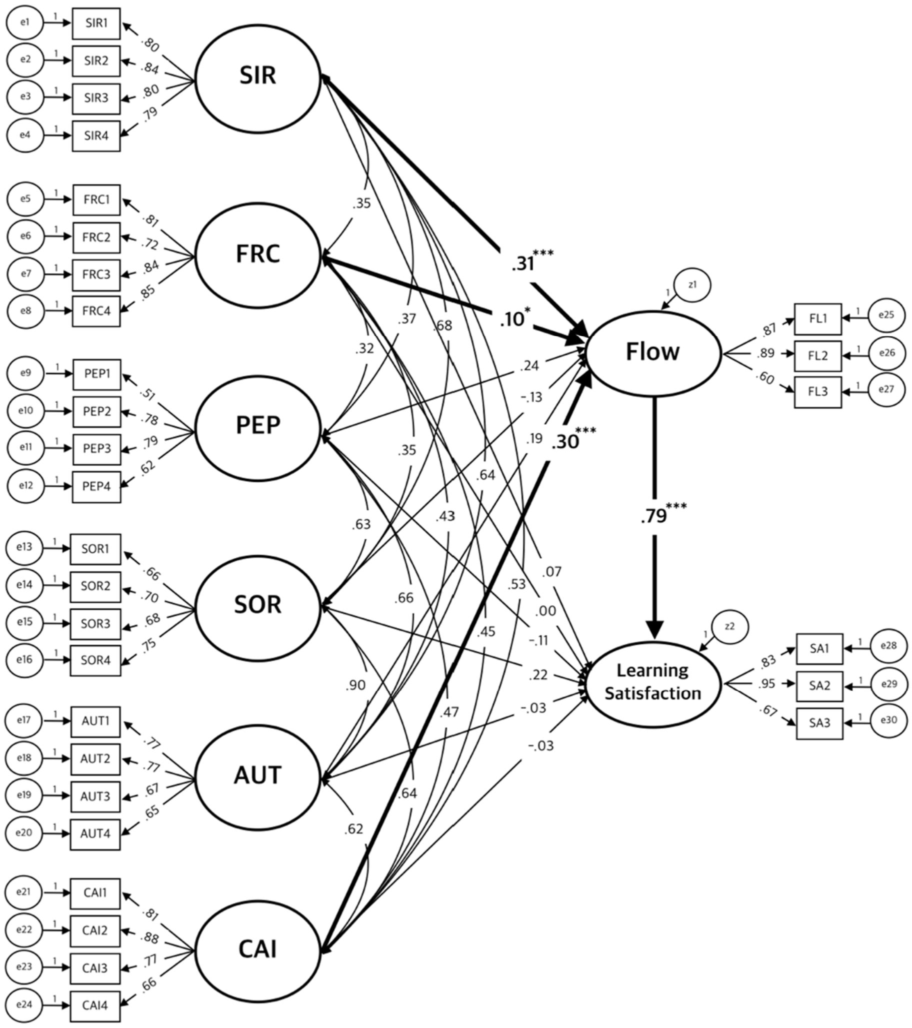

Figure 3. Parameter Estimates of the General Structural Model

The structural equation model data assume multivariate normality, so we looked at the results of a descriptive statistical analysis of each measurement variable to confirm the multivariate normality. Table 3 describes the results of the descriptive statistical analysis of means, standard deviations, skewness, and kurtosis for the measurement variables.

Each variable's standard deviation was in the range of .450 to 1.118, with skewness absolute value from .015 to .730 and kurtosis absolute value from .086 to .835. As a result, individual measurement variables had a normal distribution since the standard deviation (the reference value for rejecting the assumption of normality of the distribution) was 3.0 or higher, the skewness absolute value was not more than 3.0, and the kurtosis absolute value was 8.0 or higher. Figure 3 also portrays the relationships between the construct and observed indicators, presenting the loadings and residuals. Since each variable was normally distributed, the maximum likelihood estimation was selected as an appropriate statistical estimation method.

Analysis of the Goodness-of-Fit Test

Before conducting the hypothesis tests among the latent variables, we carried out several goodness-of-fit tests. Table 4 includes the results of each goodness-of-fit measure for the model. We conducted χ^2, the root mean squared error of approximation (RMSEA), comparative fit index (CFI) and the Turker-Lewis index (TLI) to determine the goodness-of-fit test.

Table 4. Goodness-of-Fit Measures for SEM

Fit measures	Values	Recommended value	Status
χ^2	648.874 (p = .00)	$p > .05$	Not accepted
RMSEA	.058	$p < .10$	Accepted
TLI	.914	$p > .90$	Accepted
CFI	.925	$p > .90$	Accepted

RMSEA is one of the most widely reported measures of fit in SEM applications (Kelley & Lai, 2011). It adjusts for the complexity of the model and the size of the sample and a marginal acceptance value of RMSEA is .10. CFI and TLI are comparative fit measures and greater than .9 are favorable. On the other hand, the χ^2 among the fitness test is very sensitive to the sample size, so it is not appropriate to judge that the model is not suitable based only on the χ^2 value (Hong, 2000; Kline, 2011). Evaluating all measures and considering the above statements, we accepted the general structural model and considered it sufficient for further analyses.

Meanwhile, the goodness-of-fit of the structural and measurement models was the same. In this case, the measurement model's covariance only changes to the path coefficient's set direction of the structural model. In other words, the measurement model and the structural model in this analysis are equivalent models.

Analysis of the Structural Model

Table 5 illustrates the parameter estimates for the structural model. The verification results showed that three of the 14 paths in the structural model were significant at the .001 level, and one was significant at .05. Analysis of the structural model's pathways shows that the six sub-factors of perceived game realism in GBL and the factors significantly impacting each aspect of flow and learning satisfaction are as follows. PGR's elements affecting flow are SIR, FRC, and CAI. The effect size is the largest with SIR at .314, CAI is the second at .297, and FRC is .096. All six PGR sub-factors had no significant effect on learning satisfaction. The flow had an effect of .792 on learning satisfaction.

The verification results of the structural model are as follows. First, the verified direct impact of SIR on flow is $\beta = .314$, $t = 3.474$ ($p < .001$). Second, the verified direct impact of CAI on flow is $\beta = 0.297$, $t = 3.458$ ($p < .001$). Third, the verified direct impact of FRC on flow is $\beta = .096$, $t = 1.338$ ($p < .05$). Fourth, the verified direct effect of flow on learning satisfaction is $\beta = .792$, $t = 7.792$ ($p < .001$).

In this study, we established the path for flow to act as a mediator between PGR and learning satisfaction. The analysis verification results of each path's effects showed that SIR was not statistically significant in the direct effect on learning satisfaction ($\beta = .069$). However, it was significant in the indirect effect with flow as a mediator ($\beta = .249$, $p < .01$) and in the total effect ($\beta = .318$, $p < .05$). There was no statistical significance in CAI's direct effect on learning satisfaction ($\beta = -.032$), but we did find statistical significance in the indirect effect with flow as a mediator (β = .236, p < .05), and the total effect (β=.203, p <.05).

Table 5. Parameter Estimates, T-Values, and Results of Hypotheses

Hypothesized path	Standardized estimate				Result of hypotheses
	Direct effect	t	Indirect effect	Total	
SIR → FL (H11)	.314***	3.474	-	.314***	Supported
FRC → FL (H12)	.096*	1.338	-	.096*	Supported
PEP → FL (H13)	.236	2.498	-	.236	Not supported
SOR → FL (H14)	-.130	-.538	-	-.130	Not supported
AUT → FL (H15)	.190	.816	-	.190	Not supported
CAI → FL (H16)	.297***	3.458	-	.297***	Supported
SIR → SA (H21)	.069	.840	.249**	.318*	Not supported
FRC → SA (H22)	-.003	-.055	.076	.072	Not supported
PEP → SA (H23)	-.115	-1.412	.187	.073	Not supported
SOR → SA (H24)	.220	1.-69	-.103	.117	Not supported
AUT → SA (H25)	-.028	-.143	.150	.122	Not supported
CAI → SA (H26)	-.032	-.421	.236*	.203*	Not supported
FL → SA (H3)	.792***	7.792	-	.792***	Supported

*p < .05, **p < .01, ***p < .001, FL = flow, SA = learning satisfaction

Conclusion

The following is an interpretation of the results. First, Ribbens and Malliet (2010)'s study showed that the same result was the most influential factor in explaining the PGR of SIR and CAI factors. Also, Shin (2012)'s study of educational games' flow factors found that educational effect variables significantly impacted flow; however, graphics variables did not have a significant effect. PEP, like graphics variables, also had no significant effect. Unlike the one-way characteristic of general media, the SIR, CAI, and FRC factors reflect the games' unique characteristics. This finding indicates that the learner's identification of characters that function as a student's proxy role is essential in educational games, especially when choosing the games' direction and response through characters. This suggestion is in line with Daneels, Malliet, Koeman, and Ribbens (2018)'s research, which identified CAI as the sub-factor of perceived game realism with the greatest impact on the gaming environment. Although the learner does not directly experience the character, choosing the games' direction and response through the characters is vital in educational games to increase flow experience.

Second, the study's results on whether PGR affects learning satisfaction show that flow due to SIR and CAI factors contribute to learning satisfaction in the GBL process. PEP, SIR, and FRC had relatively little effect on flow and had no direct or indirect impact on learning satisfaction. These results indicate that only SIR and CAI in GBL significantly influence flow due to the strong correlation between flow and learning satisfaction. The strong effect of flow on learning satisfaction is indirect. As a result, the more aware students are of the PGR for educational games, the more impact it has on learning satisfaction. Third, the study's results on the effect of flow on learning satisfaction are consistent with other prior studies that reveal a static relationship between GBL flow and learning satisfaction (Ryu, 2000; Baek & Kim, 2005; Ryu, 2008; Park, 2009). Accordingly, PGR factors induce flow in educational games and predict learning satisfaction.

The study has three conclusions. First, educational game developers should consider SIR, CAI, and FRC among the PGR elements to increase learners' involvement. Second, to improve learners' satisfaction in educational games, forming the flow in advance is essential and should include SIR and CAI factors. Third, since PGR in GBL shows positive effects on learning satisfaction through flow, we recommend considering PGR in developing educational games.

Future Research Direction

This study's limitations include difficulty generalizing the results due to the limited target and learning time in the GBL experience. However, this study identified a significant influence on educational effectiveness by "the degree of realism that learners perceive within a game." This effectiveness was lacking in the design and development of GBL and educational games. This awareness has recently expanded the general sense of digital gaming, considering the increasing interest in VR and improved technologies in educational games. In this situation, it was meaningful that we looked at "the degree of realism that players perceive," a major concern of VR games, in an educational game environment. In addition, considering the lack of examination of PGR in educational games, general digital game realism has been expanded to educational game research.

By analyzing a prior study on perceived media realism, presented as the source of PGR in this study, we examined the game's inherent media properties by extending them to learning effectiveness. In this light, we looked at the possibility of discussing educational games' social impact by expanding the cultural development effect. This effect was a research objective in Potter(1986)'s study of perceived media realism in the educational domain. In this study, we tried to verify whether PGR was a factor enhancing educational games' effectiveness. Specifically, we investigated PGR's six factors and the impact and structural relationship between flow and learning satisfaction.

Studies have shown that SIR and CAI among the PGR factors significantly influence flow and learning satisfaction. These results indicate that narratives such as character creation and various character stories contribute more to the overall realism and flow of educational games than audiovisual embodiments such as graphics and background music. Poor visual and auditory implementations—flagged as the reason for the absence of flow in existing educational games—have a relatively small impact on educational games' flow and learning satisfaction. Thus, to improve learners' flow and learning satisfaction in developing future educational games, designs should consider aspects of the learner's personal experience and associated realism rather than technical elements such as sophisticated graphic representation.

Acknowledgements

This study is a revision of the first author's master's thesis. We gathered research data through a questionnaire to the course students. We received the students' informed consent before data collection. We informed the students about the study's purpose, that their participation was voluntary, and that they were free to withdraw from the research at any time. Research data were anonymized before analysis for privacy. The data used in the study is not available publicly as per written agreement with participants and ethical approval. The authors have no conflicts of interest to declare concerning this work.

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Appendix

Table 6. Indicators for Exogenous and Endogenous Variables

Variable	Indicator	Measurement instrument
Simulational realism	SIR1	By playing "T" game, I can learn how certain problems are resolved in the real world.
	SIR2	By playing "T" game, I can learn something about the real world.
	SIR3	By playing "T" game, I feel better prepared to handle certain life-like situations.
	SIR4	By playing "T" game, I can learn how to control certain situations.
Freedom of choice	FRC1	While playing "T" game, I feel I' m creating my own story.
	FRC2	While playing "T" game, I feel that I determine the course of the game.
	FRC3	In "T" game, I feel that I determine the outcome of the battle.
	FRC4	While playing "T" game, I feel I can determine which path to follow in the video game world.
Perceptual pervasiveness	PEP1	In "T" game, everything looks impressive.
	PEP2	The picture quality of "T" game is incredible.
	PEP3	In "T" game, everything is depicted in great detail.
	PEP4	"T" game has a poor picture quality.(R)
Social realism	SOR1	Characters in "T" game act like persons in real life.
	SOR2	In "T" game, aspects from reality are woven into the game.
	SOR3	The characters in "T" game bear similarities with people in real life.
	SOR4	The locations in "T" game look similar to places in real life.
Authenticity	AUT1	The developers of "T" game spent great care to make sure that they built a credible world.
	AUT2	It's obvious that the developers of "T" game had an eye for detail
	AUT3	The developers of "T" game spent a lot of time and effort to make HL2 feel natural.
	AUT4	The developers of "T" game examined which objects (e.g., weapons) fit within the context of the game.
Character involvement	CAI1	While playing "T" game, it feels as if I'm present in the video game world.
	CAI2	While playing "T" game, the video game world feels real.
	CAI3	I feel that the character in "T" game is an extension of myself.
	CAI4	While playing "T" game, I experience the events like I experience events in real life.
Flow	FLOW1	The mission level of the game was not too difficult or easy for me.
	FLOW2	I clearly understood what to do in the game and what goals to achieve.
	FLOW3	The game provided adequate feedback on how I was playing.

Table 6. Indicators for Exogenous and Endogenous Variables

Variable	Indicator	Measurement instrument
	FLOW4	The user interface of the game was easy to find and use.
	FLOW5	I thought I could get good learning results in the game.
	FLOW6	I thought I wanted to experience the game again.
	FLOW7	I was so absorbed in playing games that I could concentrate on playing games.
	FLOW8	During the game I wasn't worried about what other people thought about my game performance.
	FLOW9	Time seemed to pass very fast during the game.
Learning Satisfaction	SAT1	It is enjoyable to be able to participate in this activity.
	SAT2	I like this kind of gaming environment.
	SAT3	It is very effective to learn this way.
	SAT4	Practice answering questions in the game give me a sense of satisfaction.
	SAT5	I do not like this activity.(R)
	SAT6	I can have ample opportunities to practice English through the kind of gaming instructional method.
	SAT7	I like to learn English through this kind of instructional method.
	SAT8	I hope all courses can integrate this kind of gaming instructional method to practice.
	SAT9	It feels good to be able to participate in this event.
	SAT10	This kind of gaming environment suits me pretty well.
	SAT11	I am satisfied with my performance in the activity.
	SAT12	This kind of activity gives me a sense of under-achievement.(R)