



Sustaining iterative game playing processes in DGBL: The relationship between motivational processing and outcome processing

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ABSTRACT

Digital game-based learning (DGBL) has become a viable instructional option in recent years due to its support of learning motivation. Recent studies have mostly focused on identifying motivational factors in digital games (e.g., curiosity, rules, control) that support intrinsic motivation. These findings, however, are limited in two fronts. First, they did not depict the interactive nature of the motivational processing in DGBL. Second, they excluded the outcome processing (learners' final *effort versus performance* evaluation) as a possible motivation component to sustain the iterative game playing cycle. To address these problems, situated in the integrative theory of Motivation, Volition, and Performance (MVP), this study examined the relationship between motivational processing and outcome processing in an online instructional game. The study surveyed 264 undergraduate students after playing the *Trade Ruler* online game. Based on the data collected by ARCS-based Instructional Materials Motivational Survey (IMMS), a regression analysis revealed a significant model between motivational processing (attention, relevance, and confidence) and the outcome processing (satisfaction). The finding preliminarily suggests that both motivational processing and outcome processing need to be considered when designing DGBL. Furthermore, the finding implies a potential relationship between intrinsic motives and extrinsic rewards in DGBL.

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1. Introduction

A digital game is a context in which players compete in attaining game objectives by following rules and principles. The playing process is voluntary and players need to overcome challenges to achieve game objectives (Suits, 1978). Gredler (1994) insisted that game playing should be fun and competitive to engage players in the game. In the context of digital game-based learning (DGBL), game playing becomes a "serious" activity that requires players to make series of decisions to attain learning objectives (Apt, 1970; Kebritchi & Hirumi, 2008), which allows learners to restore the equilibrium state of the game learning system via autonomous playing actions (Avedon & Sutton-Smith, 1971). DGBL has been widely adopted for instructional purposes in recent years as it might be capable of helping learners achieve intended learning objectives with enjoyable learning-by-playing process (Federation of American Scientists, 2006; Gee, 2003; Prensky, 2003). During the process, players acquire learning experiences supported by interactions in games and immersed in complex learning environments that are made possible in digital games (Johnson & Huang, 2008; Pannese & Carlesi, 2007).

Digital games possess characteristics of stimulating competition, challenge, and curiosity, which could motivate learners in a learning process (Arnone, 2003; Johnson & Huang, 2008; Kebritchi & Hirumi, 2008). Recent research has discussed extensively on how digital games might motivate learners to achieve intended learning and performance outcomes (Ke, 2008; Kim, Park, & Baek, 2009; Malone, 1981; Papastergiou, 2009; Tüzün, Yılmaz-Soylu, Karakus, Inal, & Kızılkaya, 2009). Findings of these studies mainly centered on intrinsic motivational factors in multimedia learning such as challenge, curiosity, control, and fantasy (Malone & Lepper, 1987; Westrom & Shaban, 1992) that drives learning behaviors with learners' internal events (e.g., feelings of accomplishment)(van Eck, 2006). This view, however, might not be sufficient to explain the motivational processing that learners engage in digital games. Motivational processing, as suggested by the

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theory of Motivation, Volition, and Performance (Keller, 2008), explains the dynamic and interactive relationship between motivational components that directs the effort of learning.

Astleitner and Wiesner (2004) argued that in any iterative multimedia learning process (e.g., digital game playing), learning motivation is the outcome of complex and interactive processes among all instructional and multimedia elements. Solely considering motivational factors cannot translate the fluidity of the motivational processing into practical instructional design, to enhance learning. Garris, Ahlers, and Driskell (2002) also argued that DGBL research and design not only need to identify motivational factors, but more importantly they also need to focus on motivational processing that is dependent on iterative game events. In digital games, as learners constantly interact with various game features in cycles, it is important to understand how these iterative playing cycles might influence learning motivation, and how motivational processing could keep the playing cycle going.

The knowledge of motivational processing in DGBL can also help DGBL designers better manage learners' cognitive load during the playing process. The multidimensional characteristics of digital games require learners' significant cognitive investment to process environmental and social stimuli while identifying cues for motivational processing (Huang & Johnson, 2008). If managed improperly, learners could be de-motivated by the excessive demand of motivational processing (Iyengar & Lepper, 2000; Keller, 2008), which may interrupt the learning process prematurely (Ang, Zaphiris, & Mahmood, 2007).

In addition, since all digital game systems reward players' performance (e.g., game scores), it is necessary to consider extrinsic motivation induced by external rewards or incentives when designing and evaluating DGBL (Newby & Alter, 1989). For example, learners' intention to compete with other players or the game system, as an extrinsic incentive, must be taken into account. Only identifying intrinsic motivational factors cannot fully demonstrate DGBL's motivational effectiveness.

In sum, only considering intrinsic motivational factors when designing or evaluating DGBL presents a systemic problem that could impede the attainment of learning outcome. That is, it falls short in providing holistic solutions to sustain learners' motivational processing and extrinsic motivation in highly interactive and iterative game playing processes. As a result, the learning process could be terminated owing to cognitive overload (Astleitner & Wiesner, 2004). To preliminarily address this issue, this current study intends to explore the relationship between learners' motivational processing and outcome processing grounded in the integrative theory of Motivation, Volition, and Performance (Keller, 2008). Motivational processing, in the scope of this study, refers to the Attention, Relevance, and Confidence components of the ARCS model. This process enables learners to identify achievable performance goals in the early stage of the learning process. Outcome processing refers to the Satisfaction component of the ARCS model. This processing enables learners to evaluate the equity between invested efforts and the final learning and performance outcome (Astleitner & Wiesner, 2004; Keller, 1987a, 1987b; Keller, 2008). In DGBL, outcome processing not only allows learners to evaluate the efficiency of the learning process (efforts *versus* outcome), but also guides learners' motivational processing for subsequent game playing cycles (Garris et al., 2002).

The following sections will first discuss the necessity of addressing motivational design, followed by the illustration of ARCS model of motivational design. Afterward, the MVP theory will be discussed to illustrate the conceptual relationship between motivational processing and outcome processing (Keller, 2008). Then a review of recent motivational research will also be reported to demonstrate the need to carry out motivational processing studies in DGBL.

2. Literature review

2.1. Lack of motivational design in DGBL

Motivation, which inspires goal-directed behaviors (Schunk, 1990), is the essential element to initiate and sustain learning and performance (Ames, 1992; Anderman & Maehr, 1994; Bandura, 1997; Berliner & Gage, 1998; ChanLin, 2009; Sachs, 2001; Sankaran & Bui, 2001; Weiner, 1985). Learning environments therefore need to be designed with care to provide adequate level of motivational stimuli. For example, either too little or too much learner control could lower learners' intrinsic motivation (Cordova & Lepper, 1996; Iyengar & Lepper, 2000). In DGBL, since it requires learners to simultaneously carry out numerous meta-cognitive strategies in order to process game events, too much multimedia stimuli could de-motivate learners due to overloaded cognitive capacity (Ang et al., 2007; Garris et al., 2002; Kim et al., 2009). In many cases, however, motivational components are often neglected thus discount the final learning and performance outcomes attained by learners (Keller, 1983; Spitzer, 1996). To effectively manage these problems, the design and development of motivational strategies in instructions need to be initiated early on in the instructional design process (Cheng & Yeh, 2009). Hence, the ARCS model of motivational design (ARCS model) was proposed to address this issue (Keller, 1983).

2.2. ARCS model of motivational design

ARCS model's main thesis, situated in the interactions between learners and the learning environments, is derived from the expectancy-value theory (Driscoll, 2000; Porter & Lawler, 1968; Small & Gluck, 1994; Steers & Porter, 1983; Vroom, 1964). The theory suggests that people take actions based on their expectations (beliefs) and evaluations (Palmgreen, 1984). Hence human behavior is a compound function of perceived probability for success (expectancy) and perceived impact of the success (value). In the context of learning, all ARCS-based motivational strategies therefore are developed to optimize learners' expectancies and values that drive behaviors to learn. Theoretically the ARCS model measures the amount of *effort* invested by learners to accomplish the learning task (Small, 2000; Song & Keller, 2001). Since it considers motivation development as a dynamic and interactive process, the fluctuation of one motivational component inevitably impacts all other components. Furthermore, this approach can better illustrate how learners get motivated (or de-motivated) in self-regulated multimedia learning environments than only considering intrinsic motivational factors (Astleitner & Wiesner, 2004, p. 5).

The ARCS model suggests that learning motivation is dependent on four dynamic perceptual components: attention, relevance, confidence and satisfaction (Keller, 1987a, 1987b; Keller, 2008). Attention refers to learners' cognitive responses to instructional stimuli, which should lead to learners' further effort to explore the learning task. Relevance represents the level of association learners are able to perceive between their prior knowledge and new information. The confidence level is based learners' perceived possibility to be able to successfully accomplish the learning task. Finally, satisfaction is learners' attitudes toward the value of the learning process based on a subjective

cognitive evaluation between invested efforts and received learning and performance outcomes. All four components, different from factors of intrinsic motivation (Cordova & Lepper, 1996; Malone & Lepper, 1987), work in sequence to sustain learners' motivation throughout the learning process. The sequence, which resembles the cognitive events of instruction (Gagné, 1985; Gagné, Briggs, & Wager, 1992), implies the processing aspect of motivation development.

The applicability of ARCS model has been evidenced in resolving motivational issues across learning environments. Studies have utilized the ARCS model (Keller, 1987a, 1987b) to evaluate and design instructional programs' motivational stimuli since levels of the four components of ARCS indicate how learners utilize their motivational processing capacities during the learning process (Chang & Lehman, 2002; House, 2003; Means, 1997; Song & Keller, 2001; Wongwiwatthanakut & Popovick, 2000). In a study based on 875 engineering freshmen, Huang, Huang, Diefes-Dux, and Imbrie (2006) validated ARCS model's measurements in a computer-based tutorial. Numerous attempts also targeted interactive learning environments with the ARCS model (Dempsey & Johnson, 1998; Keller, 1999; Keller & Suzuki, 1988; Klein & Freitag, 1991; Shellnut, Knowlton, & Savage, 1999; Small & Ferreira, 1994; Song, 2000). Findings of these studies revealed that the ARCS model could be applied to different learning environments to improve motivational supports of various learning environments.

Klein (1992) applied the ARCS model in the context of DGBL and conducted two experiments to investigate computer games' motivational effectiveness in comparison with traditional instructional methods. Results were consistent with prior ARCS-based studies. Dempsey and Johnson (1998) developed a computer gaming scale based on the ARCS model in a two-year study and supported the applicability of ARCS model as an instrument to measure learning motivation in DGBL. Clearly, the ARCS model can be applied to empirically investigate motivational issues in DGBL (Astleitner & Wiesner, 2004).

2.3. The integrative theory of motivation, volition, and performance

To explain the complexity of learning processes in interactive and multimedia learning environments such as DGBL context, Keller (2008) further proposed the theory of Motivation, Volition, and Performance (MVP), which integrates learning motivation, learners' action-control, and cognitive information processing in multimedia instructions, in relation to learners' performance. This theory continues to emphasize the interactive essence among elements of the ARCS model (Keller, 2008). The outcome of such interaction helps learners initiate the goal-setting sequence that is critical for sustainable learning processes. Learners at first should have a sufficient level of curiosity to explore the learning task (attention); then understand the value of the learning task (relevance), and evaluate the likelihood of attaining successful performance (confidence), to identify the performance goal. These processes, termed as "motivational processing" (Keller, 2008, p. 89), prepare learners for the follow-up actions of learning. The perceived satisfaction of the learning task, however, can only be attained at the end of the learning cycle as the result of the outcome processing (Keller, 2008). In addition to the motivational processing, learners must go through the volitional processing, motivation and information processing interface, and the information and psychomotor processing, to be able to cognitively reflect and evaluate the performance for the outcome processing (Keller, 2008). Since motivational processing is crucial at the early stage of the learning process, instructional designers must be cautious to neither overwhelm learners' processing capacity nor distract them with competing stimuli. This design consideration is central for interactive and multimedia DGBL and deserves further investigation (Astleitner & Wiesner, 2004; Garris et al., 2002).

Without understanding the relationship between motivational processing and outcome processing in DGBL, it has become challenging to design effective gaming activities to support and enhance learners' motivation during the iterative game playing cycle. To address this issue, the theory of MVP, as the integration of motivational, action-control, and cognitive learning, provides a conceptual model to hypothesize an empirical relationship between motivational processing and outcome processing. With the knowledge of this relationship DGBL designers could thus devise the optimal combination of gaming activities to address different motivational components and in turn, achieve the desired state of motivational support for learners.

2.4. Review of motivational studies in DGBL

DGBL has great potentials to engage learners in complex learning environments. Studies have suggested that not only can DGBL provide opportunities for hands-on learning, but also it is capable of embodying an eclectic group of learning theories to address different learning needs (Huang & Johnson, 2002, 2008; Pannese & Carlesi, 2007). By reviewing 55 digital games and 50 publications, Kebritchi and Hirumi (2008) suggested that DGBL could deliver gaming activities that exemplify experiential learning, discovery learning, situated cognition, and constructivist learning. Although many have discussed the design of DGBL with a focus on reducing the design complexity and enhancing learner engagement (Gunter, Kenny, & Vick, 2008; Westera, Nadolski, Hummel, & Woperels, 2008), recent motivational studies on DGBL mostly focus on intrinsic motivational factors as opposed to motivational processing. For example, van Eck (2006, p. 167) argued that in order to promote positive attitudes toward learning games, the design of games should stress Malone and Lepper's four motivational factors (i.e., challenge, curiosity, rules, and fantasy) (1987). While investigating digital games' impact on learning computer science, Papastergiou (2009) incorporated intrinsic motivational factors to measure digital games' motivational appeal. Dickey (2007) analyzed modern massively multiple online role-playing games (MMORPGs) and reached two conclusions. First, MMORPGs could provide practical design models for the creation of engaging learning environments. Second, character design and narrative environments of MMORPGs could foster players' intrinsic motivation and sustain their persistent participation in the game playing. MMORPG players' motivational processing, however, was not further discussed. The aforementioned studies also ignored the reality that all digital games come with built-in reward systems (i.e., game scores) to enhance learners' extrinsic motivation, which might impact the result of outcome processing suggested by the theory of MVP.

Some research went beyond intrinsic motivation. Using a board game, Klein and Freitag (1991) concluded that game-based learning might increase learners' motivational levels based on ARCS model. The findings, however, cannot be applied to DGBL directly since the interaction in board games is not as cognitively demanding as multimedia-rich DGBL environments. Studies also suggested that digital games could be repurposed for instructional applications as they support learning motivation in general (Gee, 2003; Prensky, 2001; Rieber, 1996). Their conclusions, however, did not specify how those games could impact specific motivational processing components. In a case

study, Pannese and Carlesi (2007) identified factors that might facilitate the integration of game playing into learning processes. Although the study generated insights regarding the self-reflection aspect of the game playing, learners' motivational processing in the game was not discussed. The lack of emphasis on motivational processing in previous DGBL studies might be due to the complexity inherent with the construct (Armstrong, 1989; Baird & White, 1982; Lee, 1990; Zimmerman, 1989; Zimmerman & Martinez-Pons, 1988). As a result, challenges for DGBL designers to effectively support motivational and outcome processing remain unaddressed.

In conclusion, to fully understand DGBL's effectiveness in supporting learning motivation, more studies need to be conducted to investigate motivational processing in DGBL, especially the dynamic interaction between iterative game playing and motivation development. Furthermore, the relationship between motivational processing and outcome processing needs to be explored, to address learners' intrinsic and extrinsic motivation in DGBL.

2.5. Research question and significance of the study

In conclusion of the aforementioned literature review, this study intends to investigate if there is any empirical relationship between motivational processing and outcome processing in DGBL. Specifically this study aims to identify if motivational processing components (attention, relevance, and confidence of the ARCS model) can significantly contribute to the outcome processing (the satisfaction component of ARCS) suggested by the theory of MVP. Understanding this relationship not only allows DGBL designers to manage instructional and multimedia elements during the learning process, but also enables DGBL design to take the advantage of digital games' extrinsic reward systems, to sustain the iterative game playing and learning cycle in DGBL.

3. Methodology

The study employed the survey research method to observe participants' responses after playing the target online instructional game. All participants were recruited from a subject pool of a public university in the United States. The following sections describe the online instructional game used in the study, selection of participants, data collection, and data analysis.

3.1. The trade ruler game

Based on existing literatures on DGBL's pedagogical elements and components of the MVP theory (Huang & Johnson, 2008; Kebritchi & Hirumi, 2008; Keller, 2008), the research team reviewed online instructional games designed for general public education various topics (e. g., Center for Disease Control, NASA) to avoid biases from commercial interests. The "Trade Ruler" game developed by the Nobel Prize Foundation was selected as the target online instructional game for two reasons. First, the interaction between learners and the game is enriched by its multimedia components and consistent cognitive activities, which would enable learners to experience full motivational and outcome processing activities in numerous game playing cycles. Second, the content of the instructional game (economic theory) is novel to the participants to ensure learners' prior knowledge will not impact their perceived motivational levels (Moos, 2009), and the learning process within the game is attainable.

This online instructional game teaches the general public about why countries need to trade with each other based on the Heckscher-Ohlin Theory, which won the Sveriges Riksbank Prize in Economic Sciences in 1977. The game is accessible online and compatible with operation systems with Flash 6 player installed on the web browser. When players access the entry page they can review the introduction and rules of the game, system requirements for playing the game, and the Heckscher-Ohlin Theory. (http://nobelprize.org/educational_games/economics/trade/) Players then can start the game on the same page. The player is the "trade ruler" of an island of his/her choice with two tasks. First, the ruler needs to manage the island's production on its labor-intensive (jeans) and capital-intensive (cell phones) products. Some islands are better for manufacturing labor-intensive products while others might be advantageous in making capital-concentrated goods. Second, the ruler needs to decide what to trade with its trading partner, to maximize the islanders' welfare. The game provides immediate feedback to the ruler's trading decisions at the end of each playing cycle. Each player has three cycles to accumulate as many scores as possible. See Appendix A for the screenshots accompanied by each step.

3.2. Measurement

The Instructional Materials Motivational Survey (IMMS) was adopted to measure the motivational processing (Huang et al., 2006). The scale consists of 36 Likert-scale survey items corresponding to each component of the ARCS model, in which 12 items measure *attention*; 9 items measure *relevance*; 9 items measure *confidence* and 6 items measure *satisfaction*. This study modified the instrument to accommodate the online instructional game setting (i.e., replacing "instructional materials" with "game"). The original grammatical structure and tone of each survey item was purposefully maintained to maintain the integrity of the instrument. Participants responded to each item on a 9-point symmetric Likert-scale (1: Absolutely Not True ~ 9: Absolutely True). See Appendix B for the *modified* IMMS for this study.

3.3. Participants and data collection

The study recruited undergraduate students from a subject pool of a public Midwestern university in the United States. All participants were novices of economic theories and taking introductory courses on educational psychology. They were required to access the target online instructional game in a computer laboratory with minimal interruption. No time limit was imposed for participants to finish the game to mimic the authentic game playing process that is self-paced and autonomous. All participants were instructed to read the intended economic theory on the entry page then proceed to the game. After completing the game, participants were redirected to an online survey program to respond to the motivational processing survey. At the end, 264 cases of responses were valid for data analysis. In average, participants spent less than 30 min to complete the study.

3.4. Data analysis

The data analysis consisted of three stages. First, principal components analysis and parallel analysis were conducted to properly validate and reduce the data (Chatterji, Sentovich, Ferron, & Rendina-Gobioff, 2002; Hayton, Allen, & Scarpello, 2004; Johnson et al., 2007). Second, the study measured the reliability of extracted sub components. Finally, based on the MVP theory, the study conducted a regression analysis to identify possible empirical relationships between observed motivational processing components and the perceived satisfaction as the result of outcome processing.

4. Results

4.1. Participants

Among 264 valid cases, 50 participants are male (18.9%) and 214 participants are female (81.1%). In terms of academic affiliations, 74% of participants are in Education and Liberal Arts, 2.3% are in Business, 7.5% are in Science, and 16.2% reported “Other” as their academic major. With regards to the age groups, 73.1% of participants are between 18 and 20 years old, 21.6% are between 21 and 25 years old, and 5.3% are older than 25 years of age.

4.2. Data reduction

All items were subjected to principal components analysis with varimax rotation to extract components. Based on the Kaiser (K1) (Kaiser, 1960) rule, components with Eigenvalues exceeding 1.0 were considered. Items with loadings higher than .60 on any factor without high cross-loadings were retained in the list. In addition, items were retained if they loaded on the factors that contained multiple items. Parallel analysis was then employed to verify the finding of PCAs.

The 1st PCA, with Kaiser-Meyer-Olkin measure of sample adequacy (KMO) at .932, extracted six components contributing to 62.13% of variances based on the K1 rule. After reviewing item loadings, 16 items were deleted from the original 36-item list. The 2nd PCA (KMO = .871) verified the improvement of accumulative variance (64.64%) after the item deletion, which extracted five components from 20 items.

A parallel analysis using 150 randomly generated datasets of the same sample size ($n = 264$) and variable numbers as the real dataset (Hayton et al., 2004; O'Connor, 2000) was conducted to verify the five components from the 2nd PCA. The result indicated that the eigenvalue of the 5th component from parallel analysis is greater than its counterpart from the 2nd PCA. Thus the 5th component from the 2nd PCA was dropped. After reviewing item loadings, only 17 items were extracted from the dataset representing four components. By comparing the retained items with the original IMMS (Huang et al., 2006), the four components consist of Attention (three items), Relevance (five items), Confidence (five items), and Satisfaction (four items). See Table 1 for extracted items and corresponding loadings and components.

4.3. Scale reliability

On a symmetric 9-point Liker scale (1: Absolutely Not True ~ 9: Absolutely True), the overall reliability of the scale on standardized Cronbach's Alpha is .88, $F(263, 16) = 55.59$, $p = .00$, indicating a strong reliability of the scale. The sub-scale reliability for Attention is .79, $F(263, 2) = 11.46$, $p = .00$; for Relevance is .85, $F(263, 4) = 67.58$, $p = .00$; for Confidence is .83, $F(263, 4) = 76.96$, $p = .00$; and for Satisfaction is .81, $F(263, 3) = 21.34$, $p = .00$. See Table 2 for item statistics.

Table 1
Extracted items and corresponding loadings and components.

No.	Item	1	2	3	4	Component
1	There was something interesting at the beginning of the game that got my attention.				.706	Attention
2	The interface design of the game is eye-catching.				.829	Attention
3	The design of the game looks dry and unappealing.				.823	Attention
4	It is clear to me how the content of the game is related to things I already know.		.624			Relevance
5	I enjoyed the game so much that I would like to know more about this topic.		.616			Relevance ^a
6	The content of the game is relevant to my interests.		.749			Relevance
7	I could relate the content of the game to things I have seen, done or thought about in my own life.		.849			Relevance
8	The content in the game will be useful to me.		.785			Relevance
9	The game was more difficult to understand than I would like for it to be.	.743				Confidence
10	The game had so much information that it was hard to pick out and remember the important points.	.800				Confidence
11	The content of the game is so abstract that it was hard to keep my attention on it.	.720				Confidence ^b
12	The activities in the game were too difficult.	.757				Confidence
13	I could not really understand quite a bit of the material in the game.	.699				Confidence
14	Completing the exercises in the game gave me a satisfying feeling of accomplishment.			.678		Satisfaction
15	I learned some things that were surprising or unexpected with the game.			.676		Satisfaction ^b
16	The wording of feedback after the exercises, or of other comments in the game, helped me feel rewarded for my effort.			.715		Satisfaction
17	If felt good to successfully complete the game.			.775		Satisfaction

^a This item measures satisfaction in original IMMS.

^b This item measures attention in original IMMS.

Table 2
Item statistics.

No.	Item	Mean	Std. deviation
1	There was something interesting at the beginning of the game that got my attention.	6.04	1.85
2	The interface design of the game is eye-catching.	6.15	2.00
3	The design of the game looks dry and unappealing.	6.56	2.02
	Attention item means	6.25	
4	It is clear to me how the content of the game is related to things I already know.	6.06	1.88
5	I enjoyed the game so much that I would like to know more about this topic.	4.48	2.09
6	The content of the game is relevant to my interests.	4.27	2.08
7	I could relate the content of the game to things I have seen, done or thought about in my own life.	4.98	2.00
8	The content in the game will be useful to me.	5.00	1.88
	Relevance item means	4.96	
9	The game was more difficult to understand than I would like for it to be.	4.79	2.05
10	The game had so much information that it was hard to pick out and remember the important points.	6.24	1.87
11	The content of the game is so abstract that it was hard to keep my attention on it.	6.59	1.96
12	The activities in the game were too difficult.	6.73	1.91
13	I could not really understand quite a bit of the material in the game.	6.08	2.27
	Confidence item means	6.09	
14	Completing the exercises in the game gave me a satisfying feeling of accomplishment.	5.50	2.01
15	I learned some things that were surprising or unexpected with the game.	5.61	1.98
16	The wording of feedback after the exercises, or of other comments in the game, helped me feel rewarded for my effort.	5.84	2.08
17	If felt good to successfully complete the game.	6.40	2.02
	Satisfaction item means	5.84	

4.4. Multiple regression analysis

Using averaged Satisfaction scores as the dependent variable (DV) and averaged scores of Attention, Relevance, and Confidence as three independent variables (IVs), the results of regression analysis suggested that Attention ($\beta = .32, p < .05$), Relevance ($\beta = .37, p < .05$) and Confidence ($\beta = .19, p < .05$) are significant predictors of the Satisfaction, explaining 43.4% of the DV variance ($R^2 = .434$). In addition, Relevance has the strongest predicting power on Satisfaction, followed by Attention and Confidence.

The effect size of the result is considered large ($f^2 = .77$) (Newton & Rudestam, 1999, p. 146). The collinearity analysis further reported an acceptable multicollinearity level among IVs (i.e., VIF < 15.00) (Garson, 2008). See Table 3 for the regression model summary.

5. Discussion

Satisfaction, in the context of MVP theory, is the result of outcome processing in which learners cognitively evaluate the discrepancy between *invested efforts* and *perceived outcome* at the end of learning process (Keller, 2008). In other words, learners try to see if the learning process is worthwhile to continue. In DGBL, learners usually go through multiple playing cycles to overcome obstacles in the game while accumulating game scores. When the perceived outcome is greater than the invested effort, learners are more likely to continue on to the next learning cycle. In this present study learners reported a moderate level of satisfaction, which implies that learners might consider the learning outcome a fair result of their invested efforts.

In the theory of Motivation, Volition, and Performance (MVP) (Keller, 2008), a full motivational learning cycle should begin with the *motivational processing* (supported by attention, relevance, and confidence). Then the *volitional processing* takes over to convert learners' intention to perform into actions of learning. Learners then enter the *information and psychomotor processing* that affords learners' cognitive information processing activities between working memory and long-term memory. Finally, the *outcomes processing* enables learners to evaluate the equity between performance outcome and invested efforts and perceive the satisfactory level of the learning. Therefore viewing the theory as a whole, the motivational processing, volitional processing, and information and psychomotor processing could individually impact the result of the outcome processing. Consistent with the theory of MVP, the regression analysis confirms the relationship between motivational processing and outcome processing supported by a large effect size. The result also suggests that the relevance component is the strongest predictor among the three while the confidence component is the weakest. Based on the observed ARCS scores in this study, learners started out with a successful motivational processing that consisted of a high attention level, a low relevance level, and a high confidence level. At the end of the learning process, however, they reported a relatively low level of satisfaction. The relevance component seemingly dominates the level of satisfaction regardless of high scores of attention and confidence, which indirectly supports the relevance component's strong prediction power in the regression model. From the instructional design viewpoint, the finding can help DGBL designers to justify the allocation of design resources on various motivational strategies. In this study, the design should focus on increasing the relevance of the game content, to optimize the result of outcome processing.

Although the significant regression model reported a large effect size ($f^2 = .77$), the motivational processing components only contributed to 43.4% of variance in outcome processing. As suggested by the MVP theory, learners' cognitive processing between motivational processing (ARC) and the outcome processing (S) plays a significant role in sustaining learners' motivation (Keller, 2008). Learners with a high level of intention to pursue the learning goal could be either encouraged or frustrated at the end of the learning process due to experienced cognitive processing activities. The unaccounted for variance presented in the regression model, to certain extent, infers cognitive processing's potential impact on DGBL's motivational effectiveness, which is consistent with concerns of not overloading learners' cognitive load in complex learning environments such as digital games (Ang et al., 2007).

Finally, the significant regression model implies a relationship between intrinsic motives and extrinsic motives in DGBL. In the study, the attention and confidence components of motivational processing were results of perceived intrinsic motives (i.e., curiosity, rules, and challenge) (Malone & Lepper, 1987). For extrinsic motivation, games' rewards to performance were inevitably included as part of the

Table 3
Multiple regression results for Attention, Relevance, and Confidence to predict Satisfaction.

Variance explained							
R	R square		Adjusted R square		Std. error of the estimates		
.659	.434		.428		1.218		
ANOVA results							
	Sum of squares		Df	Mean square	F value	Sig.	
Regression	296.37		3	98.79	66.59	.00*	
Residual	385.74		260	1.48			
Total	682.10		263				
Regression coefficients							
	Unstandardized		Standardized	t	Sig.	Collinearity statistics	
	B	Std. error	Beta			Tolerance	VIF
Intercept	.79	.39		2.02	.04*		
Attention	.32	.05	.32	6.37	.00*	.86	1.16
Relevance	.38	.06	.37	6.89	.00*	.77	1.30
Confidence	.20	.05	.19	3.86	.00*	.87	1.15

*Significant at $p = .05$.

outcome processing that all participants received at the end of each playing cycle. (See Appendix I) That is, the perceived satisfaction not only took into account of motivational processing components that cover certain intrinsic motives, but also it included learners' reaction to the extrinsic incentive to perform when they saw the ranking of his or her scores among peer players. Prior studies have proposed similar interaction between intrinsic and extrinsic motivation (Luyten & Lens, 1981) in that extrinsic rewards could affect learners' intrinsic self-regulated learning behaviors. In a computer-based math game, Newby and Alter (1989) identified that while learners are more likely to select tasks with low difficulty level in order to maximize the reward, the reward system sustains the game playing by intensifying competition between learners. Since game playing and reward is inseparable, DGBL designers must consider the potential effect of extrinsic reward on motivational processing for the purpose of optimizing the result of outcome processing. The design must strive for achieving a state of equilibrium between motivational stimuli that supports motivational processing and extrinsic rewards that is part of the overall game playing experience.

5.1. Limitations of the study

Although the present study measured learners' perceived satisfaction as the result of digital game-based learning process, the score cannot be inferred to the attainment of an overall satisfactory learning experience. As prior research in computer-based learning environments has sufficiently demonstrated, learning satisfaction consists of multiple constructs that involve learners' social and cognitive learning (Arbaugh, 2000; Jung, Choi, Lim, & Leem, 2002; Sajjanroj, Bonk, Lee, & Lin, 2008). The finding of this study can only be interpreted within the framework of learning motivation and performance suggested by the MVP theory.

5.2. Conclusion and future research

Grounded in the theory of motivation, volition, and performance (MVP), this study preliminarily confirms the implied relationship between motivational processing and outcome processing. The finding implies that the design of DGBL needs to consider motivational processing, cognitive impact, and extrinsic rewards on learners' motivation development. Simply focusing on motivational processing cannot illustrate the full spectrum of motivation development in DGBL. Future research needs to examine the theory of MVP by investigating the empirical relationship between learners' motivational processing level, cognitive effort investment level, and the outcome processing level. The extrinsic rewards of DGBL also need to be considered to advance the theoretical framework.

Appendix. Supplementary information

Supplementary data associated with this article can be found, in the online version, at doi: [10.1016/j.compedu.2010.03.011](https://doi.org/10.1016/j.compedu.2010.03.011).

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