Examining Flow Antecedents in Game-Based Learning to promote Self-Regulated Learning and Acceptance

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Abstract: Game-Based Learning (GBL) has been recognized as an essential tool for motivating students to engage in active and constructive learning. While there is a link between GBL and learning outcomes, current research evidence tends to undermine the interrelationships of concepts and oversimplify flow experience in the context of GBL. This study adopted a conceptual framework of flow in computer-mediated environments to examine the roles of specific flow antecedents, such as concentration, feedback, immersion, and challenge affecting students' self-regulated learning (SRL) and acceptance of use in a higher education GBL context. Six simple board-game style educational games covering topics at the introductory level of psychology were built for learners to play asynchronously. When students entered the games, they were given an instruction page that explained the game rules as well as the topic area if appropriate. A simple pop-up window would emerge, informing the students whether they had answered the questions correctly or incorrectly. The participants were 275 students from an undergraduate level social science class in a research participation pool. Students' opinions on the GBL were measured by validated scales that emphasized their flow experience, acceptance of use and SRL. After fitting the data to the hypothesis model, a path model was generated. The model demonstrated an excellent fit of the data with interrelations among constructs about flow antecedents, acceptance of use, SRL (consist of motivation and metacognition). The findings revealed that learners place a higher value on GBL with flow antecedents like concentration and challenge, which is linked to their learning motivation and metacognitive outcomes. Aid by GBL on knowledge gain and immersive experience are considered as the underpinnings of performance expectancy before students consider adopting GBL for their learning. In contrast to what is typical of GBL, learners primarily use GBL to improve their academic performance rather than for its immersive experience. Future studies could use the current model to develop and examine a different learning artefact, depending on its nature and study goals.

Keywords: flow, game-based learning, serious game, technology acceptance, self-regulated learning

1. Introduction

Gaming is a universally captivating phenomenon, whether as a form of entertainment or as a vehicle for learning among adolescents. Despite the lack of external rewards, people collectively spent three billion hours per week playing online games (McGonigal, 2011) and, according to a recent report, this tendency is expected to continue, with a 14% increase in gamers spending hours playing games between 2020 and 2021 (Limelight Networks, 2021).

As the popularity of this novel technique of learning grows, use of digital games in learning has been extensively researched and reviewed in this decade (Hamari, Koivisto and Sarsa, 2014) and it has been increasingly recognized as an effective mean for achieving constructive learning (Ranieri, Raffaghelli and Bruni, 2018; Alaswad and Nadolny, 2015; Sailer and Homner, 2019; Bakan and Bakan, 2018). Due to the COVID-19 pandemic, educators have been experimenting with new technologies and integrating them into various teaching methods in the context of online learning (Latorre-Cosculluela et al., 2021; Veldthuis et al., 2020). While use of digital games in learning is one of the most exciting fronts for bringing constructive learning to the learners (Koivisto and Hamari, 2019; Hung et al., 2018), educators are now interested in how it can arouse students' interest in the virtual classroom, whether synchronously or asynchronously.

It is no doubt that the use of digital games in learning belongs to the family of transformational teaching. The transformational teaching model focuses on positive engagement, collaborative learning, and student-centered learning, which inspires students' creativity to achieve active life-long learning (Slavich and Zimbardo, 2012). Although use of digital games in learning plays a necessary role in Challenge-based and scaffolding tools to help students learn (Hamari et al., 2016), it has not been distinguished independently from other constructs related

Reference this paper: Wan, K., King, V., and Chan, K., 2021. Examining Flow Antecedents in Game-Based Learning to promote Self-Regulated Learning and Acceptance. *The Electronic Journal of e-Learning,* 19(6), pp. 531-547, available online at www.ejel.org

to Game-based Learning (GBL), gamified learning in the past, such as having an overlap with the research on Serious Games (Landers, 2014). The majority of current digital games in learning research is based solely on the literature of different GBL constructs. Such a trend creates a space for more empirical research into modeling various learning constructs to develop a holistic understanding of the GBL phenomenon.

1.1 The conceptual framework in this study

There were no distinctions made between these constructs in this study, and any study that the authors classed as gamification or GBL was taken into account. As the context of this study was mostly related with the concepts of GBL, GBL would be utilized in this work to illustrate the learning with digital game. GBL in higher education is generally associated with benefits observed in learners in terms of improving their attitudes, enjoyment, motivation, and learning performance. Concerning the design of GBL, specific game elements such as points/badges, and leaderboards are recognized as integral elements in GBL for higher education (Subhash and Cudney, 2018). There are few evaluation frameworks of GBL in higher education, as current research in this area tends to undermine interrelations among concepts, such as motivation, behavioral intention, and learner's characteristics in models for predicting determinants of effective GBL. In this study, we adopted (Kiili, 2005)'s framework of flow in computer-mediated environments. This is a framework based on the person-artifact-task (PAT) model (Finneran and Zhang, 2003) contain factors in each stage of the flow. In this study, the authors modified it to fit the context of the current GBL regarding the game flow model (Sweetser and Wyeth, 2005). It aims to examine if flow antecedents and experience in GBL, such as a clear goal and a sense of control, can predict learners' knowledge acquisition, acceptance of use and learning motivation.

1.2 Purpose of the study

The current study aims to examine how flow antecedents and experience could lead to flow consequences in the context of GBL. By incorporating these constructs towards a holistic model, we wish to i) address the key flow antecedents in GBL among university students, and ii) delineate flow antecedents from the proposed framework that demonstrate direct and indirect effects on learners' attitudes toward flow consequences in GBL, particularly GBL acceptance and SRL in the higher education context.

1.3 Research Questions

1. Which flow antecedents explain and contribute to the direct and indirect effects on SRL in the context of GBL?
2. Which flow antecedents explain and contribute to the direct and indirect effects on acceptance of use in the context of GBL?

2. Theoretical and empirical background

2.1 Use of digital games in learning

As mentioned before, there is no consensus on how to define the use of games in learning, and researchers have come up with their own definitions of gamification, GBL and serious games in their research. There has been some conceptual ambiguity in the educational realm, as terminology such as gamification, game-based learning, and serious games are all regularly used to refer to the usage of games in educational situations (Landers et al., 2015; Koivisto and Hamari, 2019). Despite the ambiguity in educational field, use of digital games in learning generally shared the definition of "the use of game design elements in non-game contexts" (Deterding et al., 2011). From a service market perspective, it has been defined as "a process of enhancing services with (motivational) affordances in order to invoke gameful experiences and further behavioral outcomes" (Huotari and Hamari, 2012). The term, motivational affordances, could be found in association with information, communication technologies and gaming design as early as 2006 (Zang, 2008; Good and Robertson, 2006). In the present study, under the context of GBL, motivational affordance is a supportive component for enabling users toward the actual use of the system (Huotari and Hamari, 2012). Some popular characteristics of flow theory such as challenge, feedback, clear goal, and immersion, have been identified research on GBL in learning advantages (Koivisto and Hamari, 2019).

2.2 GBL and Flow

Affordances observed from GBL align well with the flow theory (Csikszentmihalyi, 2014). The original definition of flow described it as a state that is completely engaged in a sensation of energized attention, full involvement, and delight in the activity's process (Nakamura and Csikszentmihalyi, 2014). It comprises six dimensions including concentration, clear goal, feedback, challenge, autonomy, and immersion. The difficulty of the game

is expected to increase as the player learns the game and improves his or her skills. Flow theory is therefore applied in game studies to create concentration for the students in the lectures, according to these elements (Bakan and Bakan, 2018). Researchers constructed a game flow model for mapping elements from the original flow theory to evaluate player enjoyment of games (Sweetser and Wyeth, 2005; Kiili, 2005). Two new dimensions were added to the theory: social interaction and knowledge improvement. However, existing empirical research findings on flow were rare (Koivisto and Hamari, 2019), the definition, and measurement of flow are mixed. Some researchers defined the flow state as discrete constructs such as enjoyment (Koufaris, 2002; Zhou and Lu, 2011), concentration (Liu, Liao and Pratt, 2009; Zhou and Lu, 2011), playfulness (Lee, Yoon and Lee, 2009), or simply implemented the general term "flow experience" (Chen, Lu and Luor, 2018), within their research design and investigation. As a result, the constructs used in the 'flow' scales haven't always been consistent across studies.

2.3 SRL, learning motivation and learning Strategies of GBL

Findings on psychological and behavioral outcomes in GBL are often allied with the perception of the learning experience, academic achievement, and the mechanism of applying game elements to formal education. This mechanism has been shown to efficiently develop SRL in learners as a motivational affordance (Rutherford et al., 2018; Dichev, Dicheva and Irwin, 2020). According to the past studies, the concept of SRL was often perceived as the merge of self-motivational beliefs such as self-efficacy, task value and with self-regulatory strategies like metacognitive outcomes (Ng, Wang and Liu, 2017; Panadero, 2017; Liu et al., 2012). This combination of self-regulatory beliefs and strategies requires the application of a variety of cognitive and self-regulatory strategies, which takes more time and effort on the part of students and involves a high level of motivation on their part (Duncan and McKeachie, 2005). While learning motivation plays an important role in SRL, a GBL trends analysis revealed that it is part of a larger trend (Kasurinen and Knutas, 2018). A review also indicated that the major types of psychological theories in GBL are learning theories and motivational theories (Landers et al., 2015). The motivational theories could be further divided into expectancy-based theories, goal-setting theories, and self-determination theory (SDT). An empirical examination has proved that these theories are closely related to the theory of gamified instructional design (Landers and Landers, 2014). The theory of gamified instructional design emphasized how a game element from GBL could impact an individual's motivation in learning and produce metacognitive outcomes (Landers, 2014). It suggested that GBL played a role as a moderator in the relationship between learning content, learning motivation and meta-cognitive outcomes. Those psychological and behavioral outcomes are usually measured as motivation (Sung et al., 2017; Hanus and Fox, 2015), engagement (Hamari et al., 2016), autonomy (Zainuddin, 2018; Sheldon and Filak, 2008), social skills (Tan et al., 2016; Barr, 2017), and satisfaction (Hanus and Fox, 2015).

2.4 Technology acceptance of GBL

Learners are likely to benefit from GBL when they find its artefacts beneficial for learning. Grounded by the theory of planned behavior (Ajzen, 1985) and expectancy-based theories, technology acceptance is found on many forms of gaming platforms such as mobile games (Chen et al., 2011) and online games (Oh and Yoon, 2014). Gaming is generally considered as an information and communication technology (ICT) and the research findings on game acceptance models have been integrated with the technology acceptance model (TAM) and the unified theory of acceptance and use of technology (UTAUT) (Venkatesh et al., 2003). The UTAUT framework has been used to explore key determinants of technology adoption since 2003. Researchers reviewed eight existing models on information technology in the past and used their acceptance determinants to formulate new determinants and moderators on intention and usage. In the educational setting, the UTAUT model has been implemented for exploring key determinants of different educational technologies such as learning management systems (Marchewka and Kostiwa, 2007) and computer-based assessments (Terzis and Economides, 2011). Furthermore, the existing game acceptance models were mostly determined by the technology acceptance model (TAM) (Liu, Liao and Pratt, 2009; Koufaris, 2002; Lee, Yoon and Lee, 2009), which ignored the social environment and other determinants of acceptance in the educational game context. Although UTAUT has been one of the major updates to TAM in recent years, only a few of the GBL studies have adopted this model.

3. Methods

3.1 Study Design & Participants

A cross-sectional observation study design is employed. Participants are 275 undergraduate students, 48% of females with a mean age of 18.7 who had experienced playing the educational game platform in a Hong Kong

university. Recruited from an undergraduate level social science class, participants were students in a research participation pool towards class partial credits.

3.2 Intervention

This study adopted the Wisc-Online platform (https://www.wisc-online.com/) for developing and delivering GBL objects to participating learners. An open-source platform for all educational users since 2000. The Wisc-Online provides a vast and diverse collection of learning objects that learners and educators can create their interesting games for different subjects.

Six educational games covering topics at the introductory level of psychology were built for learners and release each game per week. These games cover a wide range types of game genres such as puzzle games, memory card games, win a million and shooting Games (Figure 1). A background description of the different indicators in flow tested in the study with the game design is provided below, along with a mapped process.

1. In games, students can only focus on one task at a time (concentration).
2. The student was shown how to start the game on a landing page (goal clarity).
3. A pop-up window would appear, informing students whether they had correctly or incorrectly answered the questions (feedback).
4. In the game, provide questions with varying levels of difficulty and, similar to a shooting game, allow the player to select the target moving speed (challenge).
5. Students are free to play at any time (autonomy).
6. Learners who participate in the shooting game may have a more immersive experience because shooting the correct target in a limited amount of time requires intense focus (e.g., 4 seconds) (immersion)
7. Because the games were MCQ-based, some of them, such as Win a Million, could be played by multiple students at the same time. The answers can be discussed among the students. (social interaction)
8. These games include the course content (knowledge improvement).

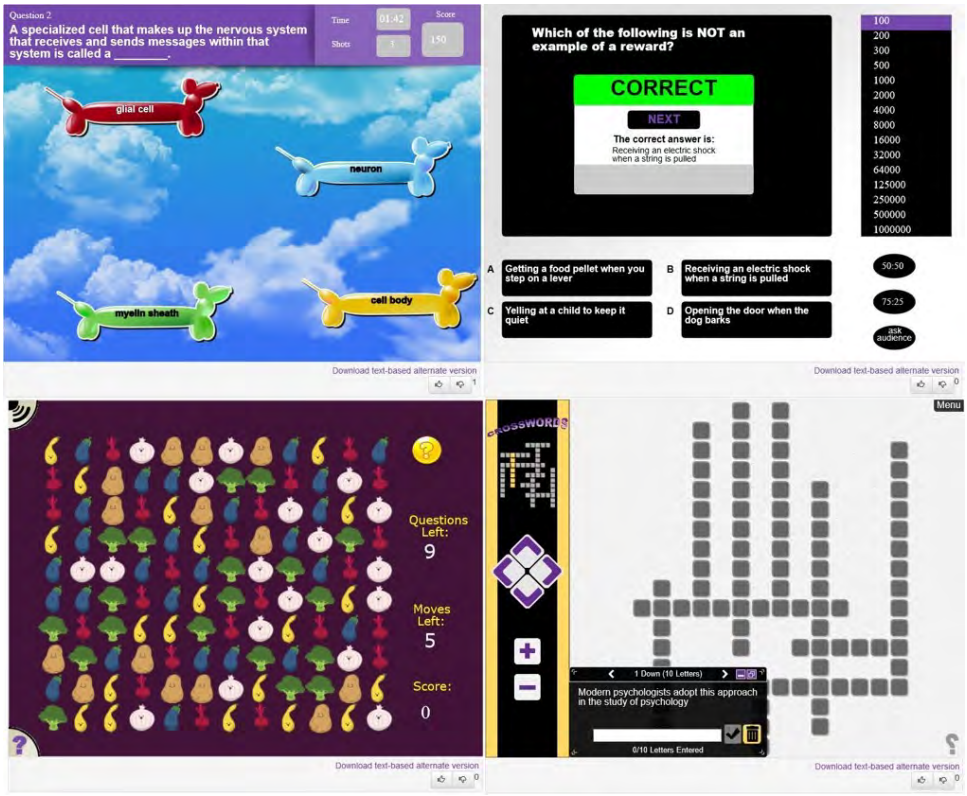

Figure 1: The Wisc-Online Games

3.3 Procedure

An online questionnaire was used to collect self-reported GBL artefact usage and ratings on constructs related to its use. Participants submitted the questionnaire through an online platform. Returns of the questionnaires were collected over four-weeks towards the end of the semester.

3.4 Measurements

There are four sets of questions included in the questionnaire (See Figure 2). Firstly, demographic information such as gender, year of study and discipline was solicited from the participants.

Instrument	Subscale	Example items
Your Personal Information (e.g., gender, age, year of study		
MSLQ (Liu et al., 2012)	Learning Strategies	When I am studying a topic, I try to make everything fit together.
	Self-efficacy	I think I will receive a good grade in this class.
	Intrinsic Value	I like what I am learning in this class.
	Anxiety	I have an uneasy, upset feeling when I take a test.
	Lack of Learning Strategies	When work is hard I either give up or study only the easy parts.
EGame Flow (Fu, Su and Yu, 2009)	Concentration	No distraction from the task is highlighted.
	Feedback	I am notified of new tasks immediately.
	Challenge	The difficulty of challenges increases as my skills improved.
	Autonomy	I know next step in the game.
	Goal Clarity	Overall game goals were presented clearly
	Immersion	I feel viscerally involved in the game
	Social Interaction	I feel cooperative toward other classmates
	Knowledge Improvement	The game increases my knowledge.
UTAUT (Venkatesh et al., 2003)	Performance expectancy	I would find the Educational Games Platform useful in my learning.
	Effort expectancy	I would find the Educational Games Platform easy to use.
	Social influence	People who influence my learning behavior think that I should use the Educational Games Platform.
	Facilitating conditions	A specific person or group is available for assistance with using the Educational Games Platform.
	Behavioral intention	All things considered, I think it is beneficial to keep using the Educational Games Platform in my class.

Figure 2: The structure and example items of the survey

3.4.1 Flow antecedents and experience

Secondly, flow antecedents and experience were measured by the EGameFlow scale (Fu, Su and Yu, 2009), a 42-item instrument with a 7-point Likert scale. It aims to explore the learner's enjoyment and the effectiveness of educational games based on a gaming model for evaluating player enjoyment (Sweetser and Wyeth, 2005) and the theory of flow (Csikszentmihalyi, 2014). The subscales correspond to the eight elements of flow experiences according to (Csikszentmihalyi, 2014)'s conceptualization of the flow theory (Table 1).

3.4.2 Flow Consequences (SRL)

Thirdly, SRLwas measured by the Revised Motivated Strategies for Learning Questionnaire (MSLQ for junior high). The MSLQ is a self-report questionnaire for measuring learning motivation and strategies (Pintrich et al., 1993). This study adopted a 28-item version, a 7-point Likert scale of MSLQ including learning motivation and learning strategies subscale (Liu et al., 2012). The motivation component measures an individual's value and belief in learning such as intrinsic motivation. The learning strategies components measures an individual's metacognitive abilities such as critical thinking and SRL. Under these two components, five subscales are named as learning strategy, intrinsic value, self-efficacy, lack of learning strategies and test anxiety.

Table 1: The EGameFlow Scale (Fu, Su and Yu, 2009)

Subscales in EGameFlow	**Definition**
Concentration	Games must provide activities that encourage the player's focus while minimizing stress from learning overload.
Goal clarity	Tasks in the game should be clearly explained at the beginning.
Feedback	Feedback allows a player to determine the gap between the current stage of knowledge and the knowledge required for the ultimate completion of the game's task.
Challenge	The game should offer challenges that fit the player's level of skills.
Autonomy	The learner should enjoy taking the initiative in game-playing and asserting total control over his or her choices in the game.
Immersion	The game should lead the player into a state of immersion.
Social interaction	Tasks in the game should become a means for players to interact socially.
Knowledge improvement	The game should increase the player's level of knowledge and skills while meeting the goal of the curriculum.

3.4.3 Flow consequences (acceptance of use)

Lastly, the acceptance of use was examined by UTAUT (Venkatesh et al., 2003). This scale includes five subscales with a 5-point Likert scale. This 20-item instrument proposes how users agree to adopt a technology tool in terms of their attitudes and behavioral intention. Those domains are performance expectancy: the perceived benefits of using the technology for a specific task; effort expectancy: the effort of implementing the technology; social influence: how peers influence the user's actual use of the technology; facilitating conditions: the technical support and surrounding environment for the users to adopt the technology; and behavioral intention: the strength of an individual's intention to perform a specified behavior.

3.5 Data Analysis

Data was analyzed with the IBM SPSS 23 software and the IBM SPSS Amos Graphics 23 software (Arbuckle, 2014). Cronbach's alpha and composite reliability (CR) were employed to measure the internal consistency of the scales. Only the α of scales >.70 were used for further structural equation modeling (SEM) (Lee, Yoon and Lee, 2009). Confirmatory factor analysis would be performed with each scale to compute the CR, average variance extracted (AVE) and maximum shared variance (MSV) for examining the discriminant and convergent validity. Descriptive statistics, correlation of existing variables and mean difference were also performed to guide the researcher to construct the present path model. A path analysis by the application would apply for modeling the inter-relations among the variables and examine the direct and indirect effects based on the following research hypothesis. The current study contained no missing data and adopted the Standard maximum likelihood estimations in the SEM.

3.6 Hypothesis

This study employed the framework of flow in computer-mediated environments (Kiili, 2005). A proposed conceptual framework was presented in Figure 3 to guide the authors in designing the research questions and the hypothesis path model.

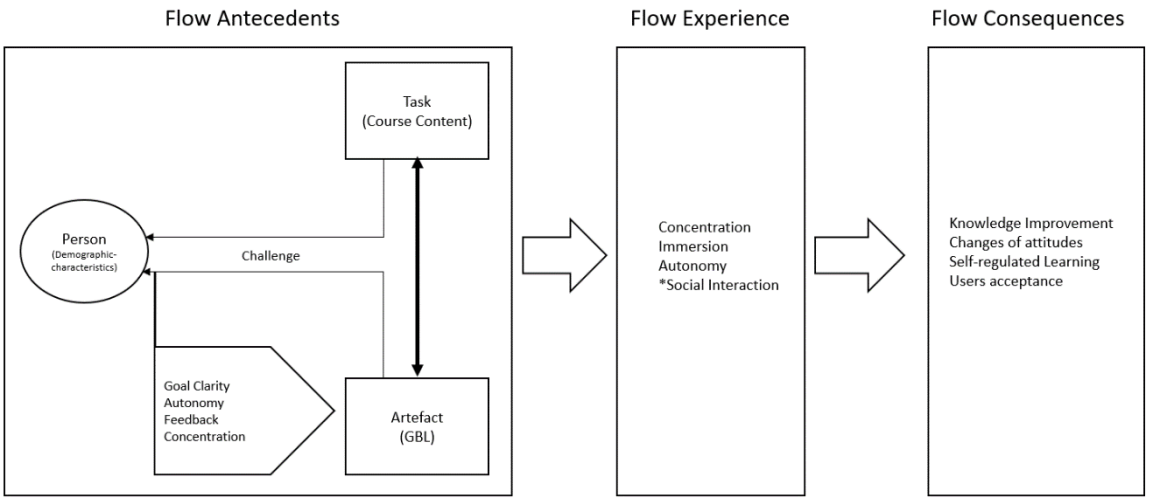

Figure 3: The proposed framework in this study. Adopted and modified from (Kiili, 2005)'s work – flow in computer-mediated environments and *item was not from the original framework

Based on the proposed conceptual framework, the following hypotheses were established to address the presented research purposes.

H_1: Flow Antecedents and experience such as concentration, feedback, challenge, knowledge improvement and immersion have direct and indirect effects on SRL (metacognitive and motivation) outcomes.

H_2: Flow antecedents and experience such as social interaction and knowledge improvement have direct and indirect effects users' acceptances.

It is hypothesized that the flow antecedents would have effects on both learning motivation and learning strategies (cognitive and metacognitive) domains. It would also examine whether those antecedents are moderators for behavioural intention. Based on the stated hypothesis, a hypothetical model is illustrated in Figure 4.

4. Results

4.1 Preliminary analysis for the path model

The correlation matrix suggested a significant moderate to strong positive association between all variables except test anxiety and lack of learning strategies (data not shown). All scales exhibited good to excellent internal consistency and are eligible for further CFA and path analysis (Table 2). Two items from facilitating conditions and behavioral intention were removed due to the poor correlation between the items and the corresponding subscales. CR from the CFA indicated satisfactory reliability. Testing results of convergent and divergent validity display acceptable CR and AVE which supported the occurrence of convergent validity in the study (Fornell and Larcker, 1981). Some of the constructs' AVE values were lower than the MSV such as immersion, which had raised the concerns on discriminant validity.

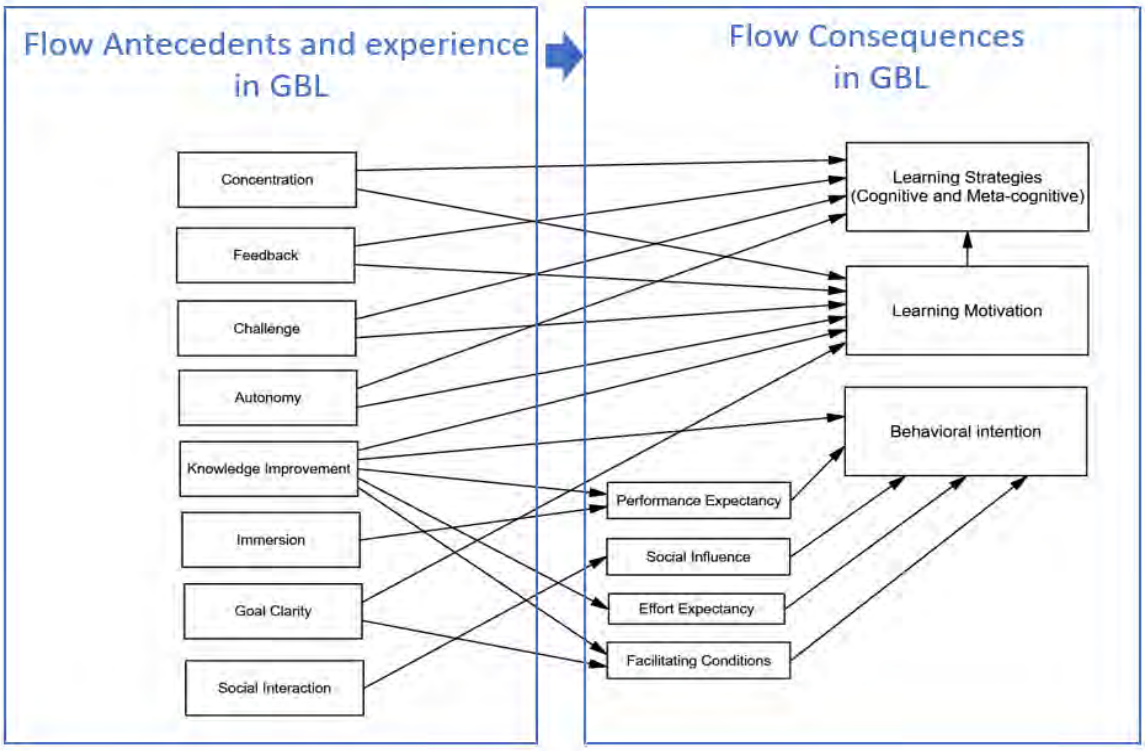

Figure 4: The hypothesized model of game flow, MSLQ & UTAUT (Fu, Su and Yu, 2009; Liu et al., 2012; Venkatesh et al., 2003)

4.2 Hypotheses testing

After modifications to the proposed model, Figure 5 illustrated the final path diagram with significant coefficients. Although preliminary results indicated gender differences, the gender variable was removed from the original model due to the insignificance and minor estimate of key variables such as knowledge improvement and effort expectancy. Upon fitting the study data, the results of the model exhibited an excellent fit ($\chi^2 = 70.939$, df = 57, $\chi^2/df = 1.245$, GFI = 0.966, AGFI = 0.929, CFI = 0.994, IFI = 0.994, RMSEA = 0.030, SRMR = 0.0366). Standardized root mean residual (SRMR) is also provided (Hooper, Coughlan and Mullen, 2008). Table 3 indicates the decomposition of effects from the path analysis. All the regression models were significant ($p < 0.05$) and the t-value > 2.33 followed by the criteria proposed by (Kline, 1998) except knowledge improvement on learning motivation. The effects of concentration ($\gamma = .256$, $t = 3.955$, $p < .0001$), challenge ($\gamma = .216$, $t = 3.378$, $p < .0001$), and knowledge improvement ($\gamma = .150$, $t = 2.279$, $p < .05$) on learning motivation were positive and statistically significant, as hypothesized. Facilitating conditions ($\beta = .158$, $t = 2.983$, $p < .005$) also contributed significant

effects on learning motivation. Of all path coefficients to learning strategies, only concentration (γ = .258, t = 5.066, p < .0001), knowledge improvement (γ = .132, t = 2.676, p < .01), and learning motivation (β = .507, t = 10.684, p < .0001) were significant. Other flow antecedents including goal clarity and autonomy yielded insignificant effects on psychological outcomes.

4.3 Direct and Indirect Effects

Table 4 provides the direct and indirect effects on learning strategies, learning motivation and behavioral intention. Only a significant effect greater than .10 would be displayed. As hypothesized, performance expectancy exhibited the strongest direct effects on behavioral intention. Knowledge improvement also had a significant modest direct and indirect effects on behavioral intention. Apart from these outcomes, the research model unveiled that facilitating conditions also involved a direct effect on learning motivation together with concentration, challenge, and knowledge improvement. Regarding the effects on learning strategies, facilitating conditions only show limited or no indirect effect while the other three domains had modest direct or indirect effects on learning strategies. Despite goal clarity having a significant indirect effect on behavioral intention, such an effect did not reach statistical significance. Goal charity only exerts a significant direct effect on facilitating conditions while knowledge improvement affected in all five domains with a significant direct and indirect effect.

Table 2: Reliability and validity of the measurement scales

Construct	Mean	SD	α	CR	AVE	MSV
Learning motivation	4.66	.93	.92	.92	.50	.61
Learning strategies	4.97	.89	.88	.88	.43	.61
Concentration	4.87	.87	.85	.86	.50	.57
Feedback	4.83	.97	.88	.88	.60	.57
Challenge	4.81	.92	.87	.87	.54	.55
Autonomy	4.71	.03	.84	.84	.64	.45
Goal clarity	4.93	.97	.90	.90	.69	.51
Immersion	4.34	1.00	.88	.88	.52	.61
Social interaction	4.50	1.08	.91	.91	.62	.61
Knowledge improvement	5.06	.90	.89	.89	.62	.46
Performance expectancy	3.63	.66	.87	.87	.63	.63
Effort expectancy	3.65	.61	.78	.78	.47	.63
Social influence	3.32	.63	.81	.81	.52	.52
Facilitating conditions^	3.64	.62	.71	.70	.44	.44
Behavioral intention^	3.68	.63	.86	.86	.68	.48

Note. ^Removed the items with poor performance (inter-item correlation r < .40 and α < .70)

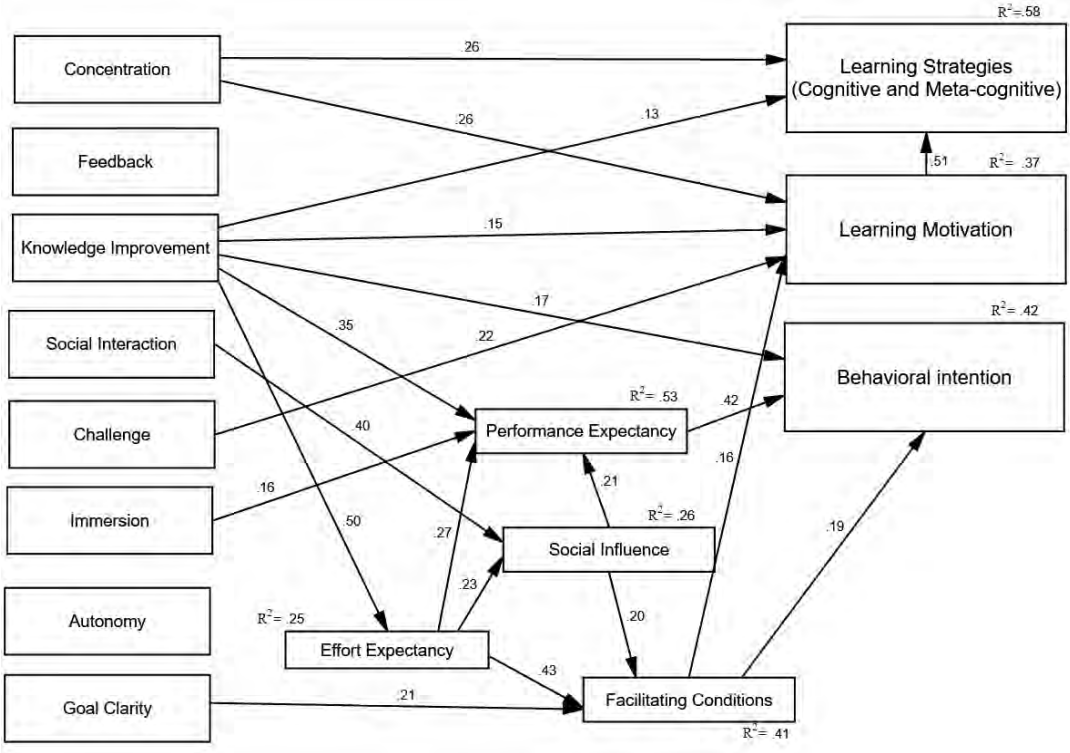

Figure 5: The research model with significant path coefficients.

Table 3: Decomposition of effects from the path analysis

Effect	Standardized estimate	*t*	R^2
On learning motivation			.368
of concentration	.256	3.955***	
of challenge	.216	3.378***	
of knowledge improvement	.146	2.279*	
of facilitating conditions	.158	2.983**	
On learning strategies (cognitive and metacognitive)			.579
of concentration	.258	5.066***	
of learning Motivation	.507	10.684***	
of knowledge Improvement	.132	2.676**	
On behavioral intention			.421
of performance expectancy	.415	6.920***	
of facilitating conditions	.190	3.683***	
of knowledge improvement	.175	2.921**	
On performance expectancy			.531
of immersion	.157	3.354***	
of knowledge improvement	.350	6.777***	
of effort expectancy	.275	5.623***	
of social influence	.210	4.600***	
On facilitating conditions			.407
of social influence	.200	4.003***	
of goal clarity	.211	4.272***	
of effort expectancy	.275	8.555***	
On effort expectancy			.248
of knowledge improvement	.498	9.508***	
On social influence			.257
of social interaction	.397	7.398***	
of effort expectancy	.233	4.336***	

Note. *$p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$

Table 4: Standardized direct and indirect effects from the path Analysis

Effect	*r*	Direct Effect	Indirect Effect
On learning motivation			
of concentration	.527**	.256	
of challenge	.501**	.216	
of knowledge improvement	.485**	.146	.038
of facilitating conditions	.390**	.158	
On learning strategies			
of concentration	.600**	.258	.130
of learning motivation	.707**	.507	
of knowledge improvement	.525**	.132	.093
of challenge	.516**		.110
On behavioral intention			
of performance expectancy	.629**	.415	
of facilitating conditions	.570**	.190	
of knowledge improvement	.526**	.175	.258
of effort expectancy	.508**		.226
of social influence	.504**		.125
On performance expectancy			
of immersion	.463**	.157	
of knowledge improvement	.616**	.350	.161
of effort expectancy	.568**	.275	.049
of social influence	.483**	.210	
On facilitating conditions			
of social influence	.498**	.200	
of goal clarity	.457**	.211	
of effort expectancy	.590**	.434	.047
of knowledge improvement	.502**	.239	
On effort expectancy			
of knowledge improvement	.498**	.498	
On social influence			
of social interaction	.472**	.397	
of effort expectancy	.364**	.233	
of knowledge improvement	.335**	.116	

Note. ** $p \leq 0.01$

5. Discussion

Results from this study responded to the call for a comprehensive framework for understanding GBL in the higher education setting (Mayer, 2014) and an update to the existing model by (Kiili, 2005) in which the effectiveness of GBL is examined in terms of inter-relationships between SRL, attitude towards GBL, and behavioral intentions. Specifically, it examined inter-relations among key characteristics of games that may contribute to psychological outcomes and produce metacognitive activities.

Hypotheses were supported partially by the results. Although preliminary results indicated gender differences, the effect is insignificant toward other variables in the model. It is inconsistent with the previous finding that male tends to have higher flow experience in serious computer game (Bachen et al., 2016). Female learners tend to perceive higher flow experience than male learners in this study. It reflected that the gender difference of flow in serious games may not completely generalizable in a GBL context.

5.1 Flow Antecedents on SRL

H_1 was partially supported by the data. Concentration, challenge, and knowledge improvement have significant direct and indirect effects on SRL, but immersion and feedback do not (Table 4).

Concentration. Learners perceived concentration as a possible approach to initiate learning motivation and accomplish higher-order cognitive activities. It appeared that concentration contributed much to the current

research model on leading learners to learning motivation and metacognitive outcomes. Such findings may inform on the design of educational games because the basic characteristics of educational games should be free from distractions and have an acceptable workload. An earlier finding pointed out that free from distraction (e.g. technological problems) environment enables students to engage more in the education games to have better learning outcomes (Admiraal et al., 2011). Noted that concentration was the second domain, next to knowledge improvement contributing to direct effects on learning motivation and learning strategies in this study. It described the role of concentration in educational gaming which was essential for fostering learners' learning motivation and cognitive and metacognitive outcomes. Prior studies have suggested that concentration is associated with flow, higher-order thinking, SRL and meta-cognitive activities (Hou, 2015; Zimmerman, 2008, 1995). A previous finding also indicated that concentration in GBL group learners was enhanced and improved the learners' cognitive load compared with non-GBL group learners (Chang et al., 2017). (Landers and Landers, 2014) discussed that learners' increased time-on-task would lead to better learning outcomes. Therefore, the current research model suggested that GBL provides a free from distraction environment with minimizing stress from learning overload to learners for sustaining focus on a specific course topic, and thus GBL facilities learning motivation and learning strategies.

Challenge. Our research model suggested that challenge predicts learning motivation. A study mentioned that the perceived challenge was a strong predictor of both learning engagement and outcomes (Hamari et al., 2016). Adopting challenge-based learning design in the GBL context was not new, but it was effective for learners' motivation and engagement (Chen and Sun, 2016). However, to further classify the foundational determinants of learners' learning motives and how they achieve meta-cognitive abilities, the challenge domain contained a small proportion of indirect effects rather than a direct effect on metacognitive abilities. This result did not align with the existing traditional framework of challenge-based learning. In this study, gamified content was at the elementary level with the simple board-game style games featured, and learners might not experience challenging tasks during their playtime. Such results suggested that learners may value the level of challenge in the existing games towards their motivation to further exploration of the course content. Yet the quality of the gamified course content may need to further be revised to crystallize their learning process into a higher-order and metacognitive manner.

Knowledge improvement. Knowledge improvement yielded the greatest effect on learning outcomes. Knowledge improvement in the present study was defined as "increasing an individual's level of knowledge and skills while meeting the goal of the curriculum". As the results pointed out the possible association between knowledge improvement and learning outcomes, the most important asset of GBL must serve the purpose of knowledge gain, which can in turn affect learners' attitudes or behavior. For example, the aim of the game should be to increase learners' meta-cognitive activities (Landers et al., 2015). Learners must spend less effort into adopting a motivational affordance to achieve the goal of knowledge gaining for better learning outcomes. It concluded that knowledge improvement was the main goal for learners to enhance their learning quality without immersion.

Feedback. It is no doubt that timely and informative game-based feedback could enhance students' engagement (McNeill et al., 2010). However, the effects of feedback in this study were limited due to the inherent nature of the GBL environment. As mentioned, the educational games featured in this study were basic online board games. When the participants answered with an incorrect response on a question, they only received a message notifying them on the correct answer choice without any further explanations. Participants might find timely feedback in these educational games insufficient. Past research has found that an informative feedback mechanism, which provides detailed and personal feedback, could improve learners' learning motivation, cognitive, and meta-cognitive performance in a rich ICT context (Chan et al., 2015; Sun, 2014; Dennen, 2005; Xie, Yu and Bradshaw, 2014; Abramovich, Schunn and Higashi, 2013; Aguilar, Holman and Fishman, 2015). It can be concluded that the digital board game had a lack of effective feedback systems such as the mechanism mentioned in previous studies. Further research could, therefore, examine how informative feedback could be effective for learners during their learning process.

Immersion. Surprisingly, immersion did not relate to any learning outcomes in this study. An experiment on serious games confirmed that learners with high game immersion helped them to master the game but not better learning performance (Cheng et al., 2017). It is expected that immersion in GBL could only be used for evaluating performance as a "game" rather than as a tool for learners to master the learning content.

5.2 Flow antecedents on users' acceptance

H_2 was partially supported by the data. Only knowledge improvement has a significant direct effect on all constructs of acceptance of use, including performance expectancy, facilitating conditions, effort expectancy, and social influence. Only social interaction has a significant direct and indirect effect on social influence. Immersion has a direct and significant effect on performance expectancy. Concentration, feedback, and challenge had no significant direct or indirect effects on acceptance of use.

We observed significant mean differences between genders in effort expectancy. Such results were consistent with the earlier findings that females exhibited strong moderating effects on effort expectancy toward behavioral intention over their male counterparts (Venkatesh et al., 2003). Yet, the effects of gender did not constitute a substantial weight in the path analysis results in the current study. Gender as a variable did not statistically predict flow and other outcomes. A strong effect of age in performance expectancy toward behavioral intention was found. Similar to the above-stated findings, younger learners tended to have a stronger effect of performance expectancy on predicting behavioral intention.

Knowledge improvement. Our model suggested that learners identified knowledge improvement directly as the goal and usefulness of GBL. The finding demonstrated that learners who played the educational games may be engaging with a pragmatic and mastery orientation, rather than seeking immersive experience on learning. As a result, the path analysis explained knowledge improvement accounted for a medium proportion for performance expectancy through effort expectancy. Corroborated with evidence on the relationship between mastery orientation and meta-cognitive outcomes (Ford et al., 1998), results from the current study echoed previous arguments that the aims of educational gaming should be focused on knowledge enhancement over gaming experience. This finding was also in line with existing previous research that learners were more engaged in flow experience by solving fewer technology problems (Admiraal et al., 2011). The knowledge improvement also connects constructs including acceptance of use and flow experience in the GBL context. While recent studies on GBL identified the importance of the contextual variable in moderating relationships between GBL and learning outcomes (Buil, 2019; Terras, 2019), we incorporated the UTAUT to incorporate such contextual variation into the model towards reported game flow and learning-related outcomes.

Immersion and social interaction. Social interaction significantly affected social influence. Immersion also indicated a slight effect to performance expectancy. As this is the first study to combine flow and acceptance of use in the GBL context, the present results echoed findings of immersion as one of the flow elements for predicting perceived usefulness (Zhou and Lu, 2011) in a mobile message usage context. Similarly, learners in the GBL context may share some of the flow experience with modern digital technology towards moderating their acceptance and use of GBL. In this study, we defined social interaction as "tasks in the game should become a means for players to interact socially". It showed that learners did not only consider whether people around them would use the system but were also concerned about whether their peers interacted with them by using the system. This result confirmed that the digital learning board games shared the core engagement aspects of traditional computer games particularly in the social perspective (McNeill et al., 2010). However, traditional GBL studies selfdom differentiate group effects (Sheldon and Filak, 2008; Tan et al., 2016; Hamari et al., 2016). As stated by a recent review (Qian and Clark, 2016), immersive and social elements are usually contributing a large effect size on learning performance, future GBL study should consider describing the learning process, addressing the advantages of collective intelligence and how immersive experience affect learners 'acceptance of use.

Goal clarity and autonomy. Goal clarity only slightly explained the facilitating condition with a rather small indirect effect on behavioral intention. This effect could be explained by the study context that students were required to complete the survey for the course continuous assessment. In addition, our preliminary results found that goal clarity had a particularly stronger correlation with knowledge improvement compared with the other flow subscales. The examination of discriminant validity also pointed out that goal clarity might be somewhat absorbed by knowledge improvement. A recent finding of goal setting in GBL reported that a specific goal turns out to yield better learning outcomes (Erhel and Jamet, 2019). Findings from related GBL studies (Hamari and Koivisto, 2014; Koivisto and Hamari, 2019) demonstrated the heavily mixed problems related to the goal, control and autonomy domains. It explains why knowledge improvement yields better results to predict learners' motivation compare with these domains. Given the interdependent nature of these two constructs, the limited effects of goal clarity observed in this study could be attributed to its covariation with the autonomy domain.

5.3 Limitations and Future Directions

This study used educational games to facilitate learners' understanding of basic social science concepts, which can be different in nature by knowing theories that are more complex. The focus of the educational games in this study is grounded at a basic level with less social interactive elements. Still, the results investigated the effect of social interaction despite the limited collaborative learning setting. Future research can, therefore, consider adopting more complicated and cooperative designs for enhancing subject interests and immersive experience. Our study focused on the ways that motivational affordances affect psychological outcomes of learning by self-report, without measuring behavioral outcomes. Nevertheless, the associations between demographic information with motivational affordances and psychological outcomes were not obvious. Some of the psychological outcomes among students, such as acceptance of use, were limited. Whether this could affect behavioral outcomes is still unknown. To further investigate the behavioral outcomes of GBL based on the current work, researchers have suggested adopting a person-centred approach to test whether learners may perform and react to educational games differently. Finally, due to the nature of path analysis is the extension of multiple regression, it may underestimate the possibilities of other clarifications like reciprocal causation (Jeon, 2015). Future researchers are suggested to conduct a latent variable structural model to clarify the effects among variables.

6. Conclusion and Implication

In response to an earlier framework of flow in computer-mediated environments (Kiili, 2005), we incorporate learning concepts and learners' characteristics into GBL from an individual level to verify the learning process in a higher education context. The model examined learners' motivation, acceptance of use as flow consequences in GBL, and how they perceived the games by examining with different flow antecedents. The finding summarized with three components, concentration, challenge, and knowledge improvement are the essential flow antecedents for explaining the learning process in GBL. GBL is an activity that requires learners to apply subject knowledge when they encounter an optimal challenge (Churches, 2008). This entire process keeps the learners at a high level of attention, which may lead to their SRL, as separated into learning motivation and metacognitive activities. This study supports the statement that GBL is a motivational affordance (Koivisto and Hamari, 2019) and motivates learners toward specific behaviors particularly sustaining their attention, providing optimal challenging subject content and space for knowledge gaining. While this study examined the basic elements of the GBL environment, future studies could be based on the present framework to investigate another learning artefact depending on its nature and research purpose.

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