VOLUME 12 ISSUE 3

Ubiquitous Learning
An International Journal

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UBIQUITOUS LEARNING: AN INTERNATIONAL JOURNAL
https://ubi-learn.com
ISSN: 1835-9795 (Print)
ISSN: 2475-9686 (Online)
http://doi.org/10.18848/1835-9795/CGP (Journal)

First published by Common Ground Research Networks in 2019
University of Illinois Research Park
2001 South First Street, Suite 202
Champaign, IL 61820 USA
Ph: +1-217-328-0405
https://cgnetworks.org

Ubiquitous Learning: An International Journal
is a peer-reviewed, scholarly journal.

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Ubiquitous Learning: An International Journal
publishes quarterly (March, June, September, December).
To find out more about the submission process, please visit
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ABSTRACTING AND INDEXING
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A Conceptual Framework for Immersion and Flow in Digital Game-based Learning: An Example of a Game-based Classroom Response System

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Abstract: Today's learning environments are providing unique challenges and opportunities for learners to interact with different technologies in meaningful, relevant, and innovative ways. The advent of digital educational game-based technologies has precipitated a growing need for faculty to engage learners and keep them motivated and challenged. In digital game-based active learning, immersion and flow are two essential elements of the player experience that occur during game play. Both these concepts are theoretically distinct, but significantly related from an empirical perspective. Immersion focuses on sensory cues that engage the player's mind via sensory stimulation, such as how involved the player is in the gaming experience and what response is expected on the part of the player. Flow centers on the cognitive aspects of the gaming experience, emphasizing the relationship between a challenging activity and the skills of a player, but also comprising of engagement, control, challenge, and feedback. A motivation for using digital games to support learning is that well designed game-based learning can provide experiences of immersion and flow, thereby simulating authentic problem-solving tasks that combine instruction, learning, and assessment. Players are immersed through interactive "game-like" activities in a competitive game play format and subsequently driven by optimally challenging tasks. Hence, digital game-based learning technologies have the means to immerse players by retaining motivation within the game by providing mastery feedback at multiple levels. Using Badaboom!, a game-based classroom response system developed by the Hong Kong Polytechnic University, this paper sets forth a conceptual framework for immersion and flow in digital game-based learning.

Keywords: Immersion, Flow, Game-based Learning, Classroom Response System, Engagement, Challenge, Control

Background

Digital game-based learning technologies are increasingly used in the educational context and a substantial body of research demonstrates empirical evidence of increased engagement, motivation, and achievement (Papastergiou 2009; Erhel and Jamet 2013; Sung and Hwang 2018). Using digital game-based learning to assist in the learning process presents a wide range of learning opportunities. For example, the use of a game-based learning platform affords players the option to learn at their own pace, through trial and error, repetition, and active engagement (Chen, Liu, and Shou 2018). In this regard, digital game-based learning has shown significant potential in the way learners perceive learning, acquire knowledge, and interpret their experiences when using the technology (Clark and Ernst 2009). Furthermore Moreno-Ger et al. (2008, 2537) explain in respect to digital game-based learning, "the designs need to balance pedagogical requirements with an elusive fun-factor." This subtle balance of engagement is what makes or breaks a game and makes the game design process a formidable task for game designers, pedagogical experts, and educators. Hence, digital game-based learning and the use of mobile technologies may offer compelling opportunities for learner engagement and interaction, yet game designers and instructional designers may not necessarily be well-versed in game design and game mechanics. Educational game designers and educators alike are

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Ubiquitous Learning: An International Journal
Volume 12, Issue 3, 2019, https://ubi-learn.com

ISSN: 1835-9795 (Print), ISSN: 2475-9686 (Online)
https://doi.org/10.18848/1835-9795/CGP/v12i03/41-60 (Article)

subsequently tasked with creating an immersive experience that is interactive and builds in feedback and assessment to engage players with different motivational orientations.

According to Plass, Homer, and Kinzer (2015, 278), "the integrated viewpoints of cognitive, motivational, affective, and sociocultural perspectives are necessary for both game design and game research in order to fully capture what games have to offer for learning." Research has shown that incorporating meaningful gaming elements and competitive game mechanics are central to facilitating successful learning outcomes (Sung and Hwang 2018; Lamb et al. 2018). However, there is no one-size-fits-all model to adopting game-based learning. Hence, there is a significant opportunity in game-based learning technologies to assess learning strategies in a way that actively encourages deeper processes of learning and interactions, subsequently challenging the player to the extent that the player is immersed in game play, and, therefore, fully absorbed in the activities of the game (Kiili and Lainema 2008). Moreover, digital game-based learning technologies are most effective when they support the experience of flow, defined by Csikszentmihalyi (2014) as an optimal experience (Chen, Liu, and Shou 2018). Hence, a state of flow is characterized by an optimum experience of complete involvement and engagement in an activity (Proulx, Romero, and Arnab 2017; Eseryel et al. 2014; Hamari et al. 2016).

Accordingly, the focus of this paper is to critically review the literature on immersion and flow and provide a conceptual framework, capturing related research in the context of digital game-based learning. Prior literature indicates that the experience of flow, when interacting with game-based technologies, consistently leads to enhanced learning outcomes, retention, and achievement (Lamb et al. 2018; Sung and Hwang 2018). For example, a study conducted by Choi, Kim, and Kim (2007) on flow experience detected a high correlation among flow experience, learning outcomes, and student's attitude toward learning within the context of a web-based learning platform. In a similar study, a positive correlation was detected between flow within a technology-based learning context and students' behavioural intention to use a web-based learning system (Liu, Liao, and Pratt 2009). Moreover, by studying immersion and flow in game-based contexts, researchers would be able to examine students' perceptions of their interactions within these game-based learning environments.

This paper offers some important contributions for a lucid and logical understanding of immersion and flow in digital game-based learning. A deeper understanding of how game-based learning methods can be effectively designed to support immersion and flow should play an increasingly significant part in improvement of learning motivation and paving the way for further research. The goal of this paper is to provide a stronger theoretical basis on immersion and flow in digital game-based learning—this could be of immense value as it could potentially provide a more solid and theoretically sound conceptual framework to guide future research in this area. The concepts of immersion and flow theory may provide key insights in terms of how digital game-based learning technologies can become persuasive and compelling building blocks for change, as well as the tools for rethinking the ways in which learning and assessment are supported. A critical requirement for any game to become successful is to attract players into the game (Chang et al. 2017; Kim, Park, and Baek 2009). Hence, the concepts of immersion and flow are seen as distinctive features that are widely used to discuss digital games and game-play experiences, particularly in respect to the development of digital game-based technologies.

This paper is organized as follows. The first part provides the background and context for game-based learning, illustrating a pedagogical model for digital game-based learning. The second part includes a discussion on the conceptual background of immersion and flow, followed by the third part which presents an overview of Badaboom!, a game-based classroom response system developed by the Hong Kong Polytechnic University. Finally, the paper concludes with a discussion on immersion and flow, two essential elements of the player experience that occur during game play for optimized game-based learning.

Introduction

Game-based Learning

In today's learning context, a variety of instructional strategies together with game-based learning technologies and their applications are being used to meet the needs of diverse learners. The application of future and emergent game-based learning technologies present numerous positive implications for learning. According to Ting, Lam, and Shroff (2019, 4), "Game-based learning is an interactive learning methodology and instructional design strategy that integrates educational content and gaming elements, by delivering interactive, game-like formats of instruction to learners." Game-based learning is based on the premise that learners have changed radically in the way in which they think and process information. More importantly, is that in order to change their patterns of behaviour and cognitive skills, learners need to be engaged and motivated in more compelling ways than before. Hence, a major issue in formal education is keeping learners engaged and motivated. Moreover, as Ting, Lam, and Shroff (2019, 4) contend, "Game-based learning integrates aspects of experiential learning and intrinsic motivation with game applications that have explicit learning goals, thereby allowing learners to engage in complex problem-solving tasks and activities that mirror real-world, authentic situations." The use of game-based learning has radically shaped learners' preferences and abilities—game-based learning should aim to develop students' abilities to think, solve problems, and become independent learners.

A Pedagogical Model for Digital Game-based Learning

Next, we look at a pedagogical model for digital game-based learning by applying Kolb's Experiential Learning Model. According to Kolb's (1984) Experiential Learning Theory, learners who are more inclined toward abstract methods of perceiving information are typically more disposed to logical analysis and abstract reasoningand tend to pursue the ideological theories that support an action (Kolb and Kolb 2005). Whereas learners who prefer concrete methods for perceiving information typically desire to participate with others and make decisions based on what intuitively feels correct. Kolb (1984) suggested that learners differ in how they process information and reflective learners typically prefer to focus on understanding and generally excel at gathering information and presenting many alternatives from diverse viewpoints. Moreover, active learners prefer to process information based on practicality and are interested in what will work and not necessarily why it will work. Active learners want to see results and are quick to get involved in problem-solving strategies (Kolb 1975).

Figure 1 presents a conceptual framework of the four learning styles, learning modes, and learning environments proposed by Kolb (1984). These include the affective, symbolic, perceptual, and behavioural learning environments, which are discussed below in relation to their application to digital-game based learning (Sung and Hwang 2018; Richmond and Cummings 2005).

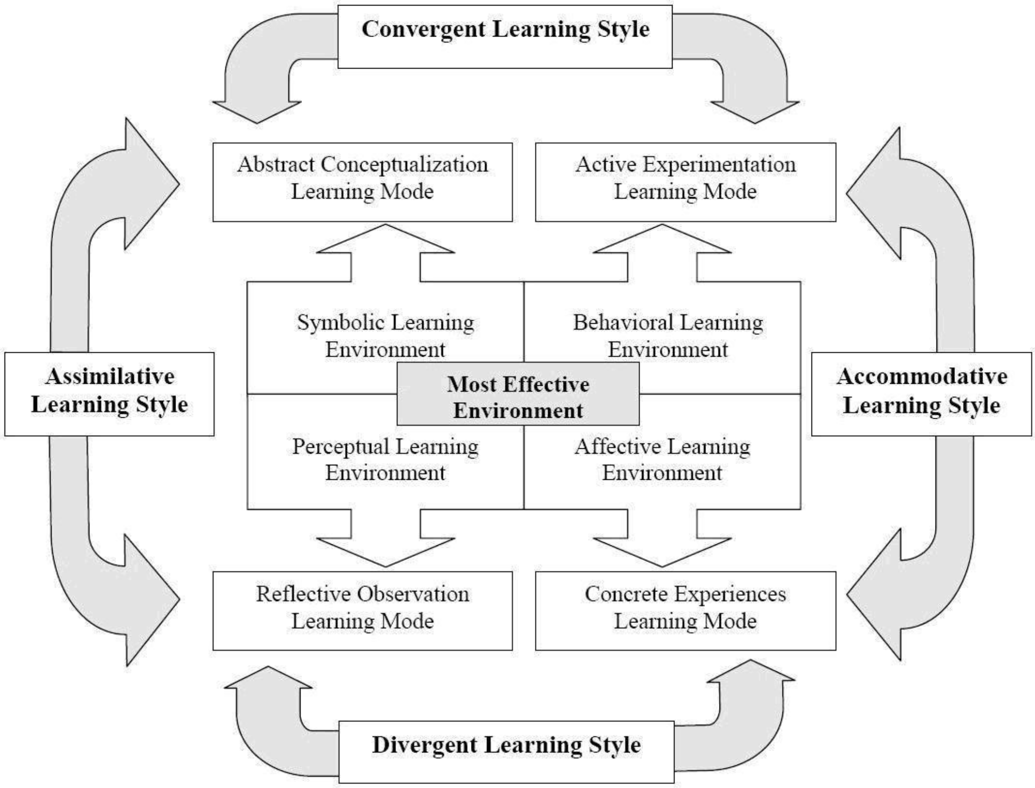

Figure 1: Conceptual Model of Kolb's Learning Styles and Learning Environments
Source: Richmond and Cummings 2005

The affective learning environment stresses the importance of concrete experiences (Richmond and Cummings 2005). For example, when applied to a digital game-based learning context, affective learning tasks include activities such as role-playing and simulations. Role-playing games (RPG) allow players to interact with a game world by assuming the role of a virtual character within a fictional setting or environment to conquer specific challenges. Through such games, players are subsequently able to identify with the character whose skills are managed through game mechanics and strategies.

The symbolic learning environment emphasizes learner involvement in trying to solve problems through some form of reasoning—inductive, analogical, or deductive (Richmond and Cummings 2005). For example, in a digital game-based learning context, a symbolic learning experience involves players anticipating the strategies used in the game and relating those strategies to key concepts in the course. One of the features of symbolic learning in a game-based context is a marked improvement in progression, whereby the player is presented with a sequence of challenges with sufficient variability and is informed of his or her progression toward the goal.

The perceptual learning environment is characterized by a fundamental goal of identifying and understanding relationships among concepts thus emphasizing the process of reflective observation (Richmond and Cummings 2005). In a digital game-based learning context, a perceptual learning experience allows players to make close connections between observation and action—this suggests that taking in a combination of auditory, tactile, kinesthetic, and dynamic visual elements allows players to fully immerse themselves in the game.

Finally, the behavioural learning environment suggests that learning occurs through reinforcement (Chen et al. 2009; Richmond and Cummings 2005). In the context of game-based learning, factors inherent in game reinforcement include skill level and changes in game difficulty, which is as much a function of the player as of the game. In a study conducted by Chumbley and Griffiths (2006), the results demonstrated that skill and in-game reinforcement characteristics had a significant impact on excitement and frustration. Moreover, the study found that game reinforcement characteristics had a significant effect on the "playability" of the game and an increase in positive reinforcement was related to a greater propensity to continue and return to play and vice versa (Chumbley and Griffiths 2006).

The effectiveness of game-based learning has been widely studied in the research literature, but the motivational elements underlying them need to be explored in greater depth. For example, a preponderance of research in game-based learning has focused on examining the social, psychological, and physiological effects of game play and how gamification elements can be applied to make the learning process interactive and engaging for learners (Ifenthaler, Eseryel, and Ge 2012). Digital game-based technologies offer exciting educational opportunities within an augmented learning environment, thereby supporting active learning and engagement with technology. However, as we will explain below, digital game-based learning technologies should be applied in a manner that reinforces learners' interactive engagement and achievement though the experience of immersion and optimal flow (Hamari et al. 2016).

Two concepts that are closely intertwined and extensively researched to explain why games are so engaging and sometimes addictive to the players are immersion and flow (Lindley, Nacke, and Sennersten 2008). It has been argued that flow is comparable to the highest level of immersion achievable, which Brown and Cairns (2004) term being in a state of "total immersion." However, due to the different definitions and understandings of immersion and flow, both these concepts have often suffered from inconsistent interpretations and conceptual overlap. Hence, the study of these two concepts are essential to the understanding of how learners engage in the learning process as immersion and flow are considered to be critical factors in the context of game-based learning (Elliott et al. 2000).

Conceptual Background of Immersion

The concept of immersion has been extensively studied in gaming literature and is considered a key feature of the game-play experience (Hamari et al. 2016; Cheng, She, and Annetta 2015). However, the meaning of immersion and how it is conceptualized remains ambiguous. Game designers, developers, and researchers use the term, but typically in an obscure and unclear manner without discernibly affirming what types of experiential behaviour or phenomena it unequivocally refers to. Immersion is a central feature in the digital gaming experience, a compelling user-controlled experience in which players engage directly through a digital medium (e.g., personal computer, game console, mobile device, etc.) (Cairns, Cox, and Nordin 2014). In a game-play context, immersion is a fundamental element of game-play experience and clearly distinct from the concept of flow. Immersion can be characterized by the game's intent to stimulate a sense of actually being a part of, or feeling a sense of presence, in a game-play situation. Immersion is the subjective perception of interactivity and the perception of the game's realism (Dede 2009). This indicates the extent to which a player feels absorbed by or engrossed in a particular experience (Cheng, She, and Annetta 2015). Moreover, game play allows the players to immerse themselves in a virtual world or a simulation of a real world interaction and experience. Immersion is a cognitive experience that takes place at various levels (e.g., progressively increasing difficulty or different skill levels) in game play and is a significant indicator of the degree of interactive engagement between the game and the player. Brown and Cairns (2004) performed a qualitative study by analysing players' feelings toward their desired game and proposed three progressive and sequential levels of player immersion: engagement, engrossment, and total immersion.

Engagement

Engagement, the first level of immersion, is a significant component of the player experience (Abdul Jabbar and Felicia 2015). In a study conducted by Brown and Cairns (2004, 1298), a definition of engagement was formulated in the context of game play as the "lowest level of involvement with a game and must occur before any other level" Moreover, player engagement can be influenced by different game characteristics; for example, the presence of competitors or being part of a group effort may increase engagement. Engagement in a gaming context can be defined in terms of players' desire to continue playing in a game (Wiebe et al. 2014). Furthermore, engagement is comprised of two dimensions: cognitive and physical engagement (Hu et al. 2016). Cognitive engagement is the degree to which the player expends the mental effort to master the game (Ke, Xie, and Xie 2016). Physical engagement is the physical effort exerted (e.g., controllers that impose different amounts of task-control movements) by players to accomplish strategic missions, goals, or tasks in the game world (Hu et al. 2016).

Engrossment

Engrossment is the second level of immersion whereby the emotional characteristics of the player are directly influenced by the game (Cheng, She, and Annetta 2015). Engrossment is an absorbed state of mind in which the player has already invested emotionally into the game, and subsequently becomes enthralled in a fantasy world of gaming through quests and unpredictable challenges (Bianchi-Berthouze 2013). Engrossment is linked to the player's sense of presence in the game, their perception of realism and the desire to play the game with a complete unawareness of their surroundings (de Oliveira, de Oliveira, and Tavares 2016). For example, research has shown that realism has an effect on engrossment of the player (Jennett, Cox, and Cairns 2008; Shin 2017). This realism is what is termed "spatial presence," which generally refers to the player's meaningful representation of themselves through self-portrayal onto a game character within a virtual world. In effect, the player transforms into the character (Rahman, Nordin, and Denisova 2017).

Total Immersion

The final level of immersion comprises of total immersion with the game, requiring the highest level of attention (Ermi and Mäyrä 2005). Total immersion is conceptualized as a feeling of being completely involved in a virtual context (Biocca and Delaney 1995). Biocca and Delaney (1995, 57) define total immersion as the "degree to which a virtual environment submerges the perceptual system of the user." This suggests that cognitive processing of emotion and associated regulation of emotional states involved in game play enables the players to be completely absorbed in their fictional surroundings. Moreover, if the player is adequately skilled and the game-play tasks and game logic have clear rules and objectives, the player will subsequently feel in control over the situation—the result is the player being completely absorbed in the game, thereby causing the player to be totally disconnected with the outside world (Sweetser and Wyeth 2005). The only thing that matters to the player is the game. As asserted by Brown and Cairns (2004), total immersion is typical of first-person perspective games and occurs when the player is able to empathize with the game character and begins to identify with a game character and also assume the role of a character. Lombard and Ditton (1997) contend that psychological immersion takes place when the player feels completely absorbed in a task in a way that leads to a sense of heightened engagement and engrossment. Furthermore, the perception of realism drives the games visual aesthetics reinforced by its designs and mechanics, and in turn, influenced by the player's sense of virtual presence. This perceived sense of realism can intensify the immersive experience as the context is more relatable to the player.

Furthermore, researchers have posited that player's skill level leads to higher levels of immersion because the player's skills enable the player to effortlessly navigate the game's interface and its challenges, thereby providing the player with a highly immersive game-play experience (Hamari et al. 2016). When in an immersed state, players are completely engrossed in their fictional surroundings. The SCI model proposed by Ermi and Mäyrä (2005) differentiates an immersive game-play experience into three key dimensions: sensory, challenge-based, and imaginative immersion. The model presented in Figure 2 illustrates the three dimensions of immersion in order to describe the game-play experience.

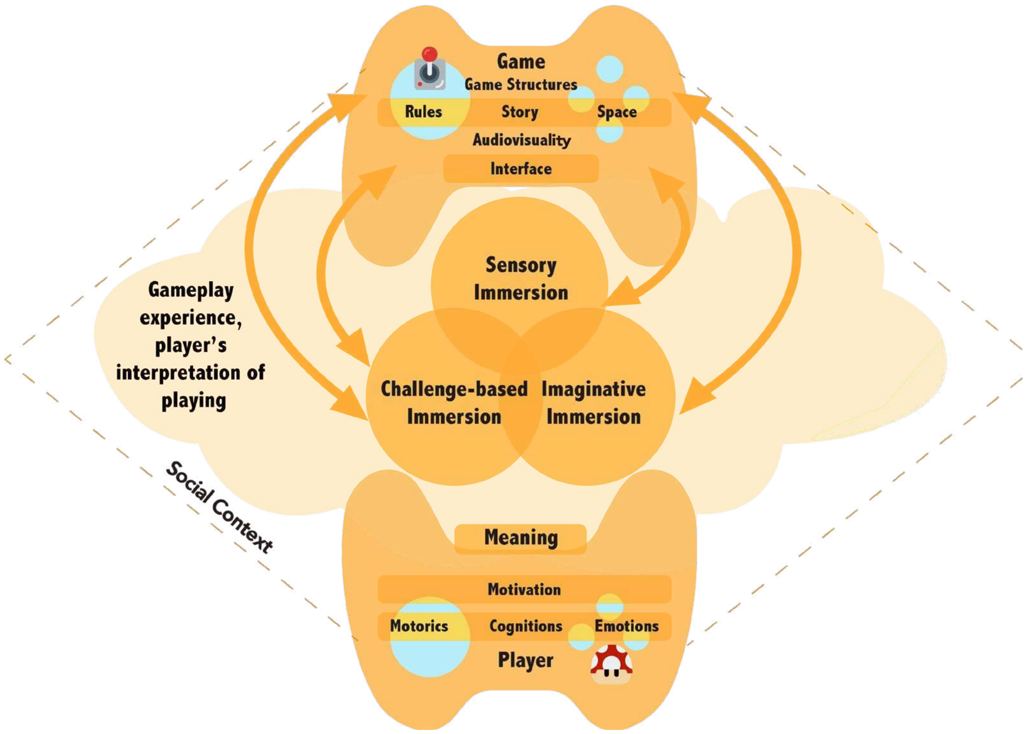

Figure 2: SCI Model Identifying the Three Key Dimensions of Immersion
Souce: Ermi and Mäyrä 2005

Sensory Immersion

Sensory immersion is a variant of immersion within a game-based and/or virtual environment in which player's senses are immersed into that environment—it pertains to the multi-sensory aspects of a game, such as graphics or sound (Ermi and Mäyrä 2005). When a game is truly immersive it is said that player is drawn into the game and its story and is subsequently engulfed in its sensory output (Kivikangas et al. 2011). This sensory output is based on the auditory and visual processing of game stimuli, achieved through realistic visual environments and sounds to help draw the player into the game-based and/or virtual environment (Lindley, Nacke, and Sennersten 2008). Hence, from the player perspective, sensory immersion is achieved when the senses of the player are stimulated more by the virtual environment than by the real world, leading to heightened believability through interaction.

Challenge-based Immersion

Challenge-based immersion is based on the challenging aspects offered by a game and the skills required in order for a player to perform to their potential (Hamari et al. 2016). Challenge-based immersion pertains to the challenges the player must overcome and the process of mastering the game. For example, when players are given the opportunity to problem solve, they become more deeply immersed into the game experience. Challenge-based immersion takes place when a player successfully accomplishes a rewarding balance of challenges and abilities—players are continually faced with challenges, and it is the persistence and the relentless pursuit of overcoming the challenges that keeps them playing. Essentially, player’s perception of being challenged increases when they experience success at challenging game-based activities, which in turn enhances their capacity for motivation toward the activity.

Challenge-based immersion requires the task to be within the player’s perception of cognitive ability, which in turn may have a positive effect on the player’s cognitive function. Hence, players learn best when they immersed in game-based tasks that challenge their current intellectual abilities, meaning that the tasks should not be too difficult for them to master (Piaget 1952). However, if the challenges of a game-based task are beyond the player’s level of ability, a feeling of anxiety could manifest. Moreover, when engaged in game-based learning tasks, the players are aware of the challenging nature of the tasks and are subsequently able to set the necessary course of action in order to deal with the perceived challenges.

Imaginative Immersion

Imaginative immersion happens when a player identifies with a game character and is characterized by the highest point of the player’s emotional attachment to the character (Poels, De Kort, and Ijsselsteijn 2007). Imaginative immersion is linked to the player’s application of imagination, empathy with characters or fantasy of the game. Imaginative immersion is typical of role-playing games whereby players are able to role play various entities ranging from individuals to entire nations and even civilizations. Both role identification as well as the cognitive process of imagination are important elements that provide an immersive experience. For example, a player is able to identify him or herself with a game character and subsequently immerse him or herself into the game world as an avatar or character defined by the player. It is this experience of role-playing, whereby players simulate how they would respond in situations and interact with others, that allows the player to become completely absorbed by the game’s story and identify with the games characters. Hence, for a player to be fully absorbed by the game’s story, the player must be fully immersed in the experience.

Conceptual Background of Flow

“Flow,” an optimal state of consciousness, is achieved by allowing a player to make choices and strategic-level decisions and to adapt to the changing conditions and challenges of the game. Flow, regarded as one of the most significant psychological outcomes of gamification and games, is characterized as a state of optimal experience in which the player is fully engaged in the task at hand. Research specifically on collaborative, mobile, augmented reality learning games has shown that engagement and flow are interrelated. Moreover, a balance between challenge and skill is a fundamental element for ensuring a conducive environment for flow to occur (Engeser and Rheinberg 2008). Specifically, game-based learning holds the promise of engaging players by creating the conditions for flow during game play.

Within the game-based learning context, various frameworks of flow have been developed and used in order to develop greater understanding of the concept of flow. A model of flow proposed by Novak and Hoffman (1997) added the construct of perceived control and challenge to develop a predictive model of flow experience. From this perspective, players attempt to demonstrate a sense of control over the game activity through progression and feedback. As a result, the players persist at game-based activities that provide them with an opportunity to make choices and to control the outcomes emanating from those choices. Moreover, according to the concept of flow, players, at any given moment in the game, are cognizant of a variety of challenge-based opportunities presented to them while they gauge how competent and skilful they are in effectively dealing with the challenges (Csikszentmihalyi 1988). As such, an individual's perceived challenges may facilitate the occurrence of flow. If, however, the challenges of a task are beyond a player's level of ability (i.e., they are more than the player is able to deal with), a physiological, psychological, and emotional state of anxiety takes hold. In contrast, if the challenges are lower than a player's ability, boredom can result. Moreover, an important component of challenge is the amount of cognitive effort required to overcome the challenge (Cowley et al. 2008). This indicates the importance of player balancing, whereby the game is balanced between game challenge and player skill in order to make the game more competitive and engaging.

Results of previous studies (Moneta and Csikszentmihalyi 1996; Haworth and Evans 1995) have shown that activities that were perceived to be challenging had a positive effect on the quality of experience of an individual. Moreover, how challenging a task is, as is experienced by an individual, is fundamental in predicting optimal experience as well as boredom and anxiety. In game design, for example, game designers should have a deep understanding of game mechanics in which the element of challenge is continually sustained, thereby allowing the player to be challenged through repeated play sessions and so that player's skills improve over time. Furthermore, in game design, adapting to the challenges of different players' needs is a key element for long-term player engagement and retention. Depending on players' personal goals, players may feel demotivated and eventually lose interest in continuing to play a game that is too easy and subsequently does not challenge their cognitive abilities or provide sensory stimulation (Unsworth et al. 2015). Conversely, players may not have the motivational drive to play a game that is too complicated and complex to master. Hence, in order to draw in and keep player's interest high, it is necessary to find the right balance between game challenge and player skill—this is directly tied with challenge-skill balance, an important element in immersion and "flow" experience (Engeser and Rheinberg 2008). Table 1 below summarizes the dimensions of flow and immersion and primary proponents.

Table 1: Dimensions of Flow and Immersion and Primary Proponents

Theory	*Application*	*Dimension*	*Author(s)*
Flow	Human Psychology	1. Optimal experience; 2. Control of consciousness; 3. Psychology of discovery; 4. Autotelic personality	(Csikszentmihalyi 2014)
Flow	Online environments	1. Consumer behaviour; 2. Skill, challenge, and play; 3. Flow/apathy; 4. Control/worry; 5. Arousal/relaxation; 6.Anxiety/boredom	(Novak and Hoffman 1997)
Flow	Cyber-game addiction	1. Users compulsive use; 2.Concentration; 3. Time distortion perception; 3. Playfulness; 4. Exploratory behaviour	(Chou and Ting 2003)
Flow	Human-computer interactions	1. Time distortion 2. Enjoyment; 3. Telepresence	(Skadberg and Kimmel 2004)
Flow	Engagement in information-seeking activities	1. Joy of discovery; 2. Distortion of time; 3. Integration of action and awareness; 4. Control; 5. Mental alertness; 6. Telepresence	(Pace 2004)
Flow	Game play	1. Concentration 2. Challenge; 3. Control; 4. Clear goals; 5. Feedback; 6. Immersion; 7. Social interaction	(Sweetser and Wyeth 2005)
Immersion	Computer game narrative	1. Curiosity; 2. Concentration; 3. Control; 4. Challenge; 5. Comprehension; 6. Empathy	(Qin, Patrick Rau, and Salvendy 2009)
Immersion	Game	1. Engagement; 2. Engrossment; 3. Total immersion	(Brown and Cairns 2004)
Immersion	Game-play experience	1. Sensory immersion; 2. Challenge-based immersion; 3. Imaginary immersion	(Ermi and Mäyrä 2005)
Immersion	Measuring immersion in games	1. Engagement; 2. Engrossment; 3. Total immersion; 4. Cognitive absorption; 5. Presence; 6. Sub-optimal experience	(Jennett et al. 2008)

Source: Data adapted by Shroff et al.

Immersion and flow are two of the most significant concepts that have been widely studied in the game-based learning literature. Conversely, immersion and flow have features that are distinct and yet related to each other. Though both are conceptually different, they are in effect, empirically strongly related. Table 1 above summarizes the primary proponents and applications of immersion and flow theory, illustrating the various dimensions that have been studied. The term "optimal experience" coined by Csikszentmihalyi (2014) is characterized by the perception that one's skills are balanced to the challenges at hand. Moreover, Csikszentmihalyi (2014) contended that flow results in increased learning and exploratory behaviour such as seeking variation in a task or activity, discovery, and imaginative thinking, such as problem solving and incidental learning. Skadberg and Kimmel (2004) found telepresence (i.e., players feel they are part of the action) to be an important characteristic of flow and provided evidence and justification for the use of telepresence, time distortion, and enjoyment as the measurement variables of flow. In a qualitative study, Brown and Cairns (2004) interviewed seven gamers with the aim of forming a clear and precise definition of immersion in the context of game play. Consequently, their research study identified the following three distinct levels of immersion which have been discussed above: engagement, engrossment, and total immersion (Brown and Cairns 2004).

Immersion and Flow in a Game-based Classroom Response System

We now present an overview of Badaboom!, a game-based classroom response system developed by the Hong Kong Polytechnic University. Inspired by the gamified quiz application, Kahoot!, Badaboom!, a web-based classroom response system based on the arsnova.click open source project, was developed for instructors to use in the classroom setting by engaging students in the active learning process through use of problem-solving activities that evoke interest as well as activities that encourage feedback. Badaboom! offers gamification elements such as nicknames, sound, countdown, degree of certainty, and ranking lists. Similar to Kahoot!, Badaboom! integrates a "game approach" into the traditional lecture class by integrating various gaming elements such as goals, rules, timing, reward structures (e.g., points), and feedback. Some of the gamification elements include a virtual quiz lobby (with selectable background music), whereby the nicknames of incoming players are displayed as players wait for the quiz to start as well as a display of incoming votes including players' average confidence level, thus making for a more engaging and meaningful learning experience. As we will explain below, to unleash the full potential of Badaboom!, the system was designed and applied in a way that it arouses both an immersive player experience as well as flow-oriented behaviour.

In contrast to Kahoot!, Badaboom! offers a selection of question types that include multiple choice questions and surveys, thereby allowing students to input answers, respond with numeric and text answers in addition to sketching, graphing, and uploading images and text. A significant limitation of Kahoot! is that it only allows four answer choices for students to choose from, Moreover, Kahoot! does not allow for open-ended questions in which students are able to key in their own responses. The pedagogical value of Badaboom! has been further enhanced by adding new functionalities that allow for images, emoji, TeX (a mathematics type setting system) formulas, and videos from YouTube and/or Vimeo to be embedded in question and answer choices. The Badaboom! game-based platform was embedded into a basic mathematics undergraduate course offered by the Department of Applied Mathematics at the Hong Kong Polytechnic University to engage students through problem solving and critical thinking regarding mathematical concepts. The course provided students with a clear understanding of the basic concepts and applications of elementary differential calculus with emphasis on the use of mathematical techniques in tackling practical problems in science and engineering. Emphasis was placed on the understanding of fundamental concepts and the use of mathematical techniques in handling practical problems in science and engineering. The integration of a LaTex Equation editor and recognition function in Badaboom! was especially appropriate to the course, allowing students to write equations using appropriate symbols and fraction notation.

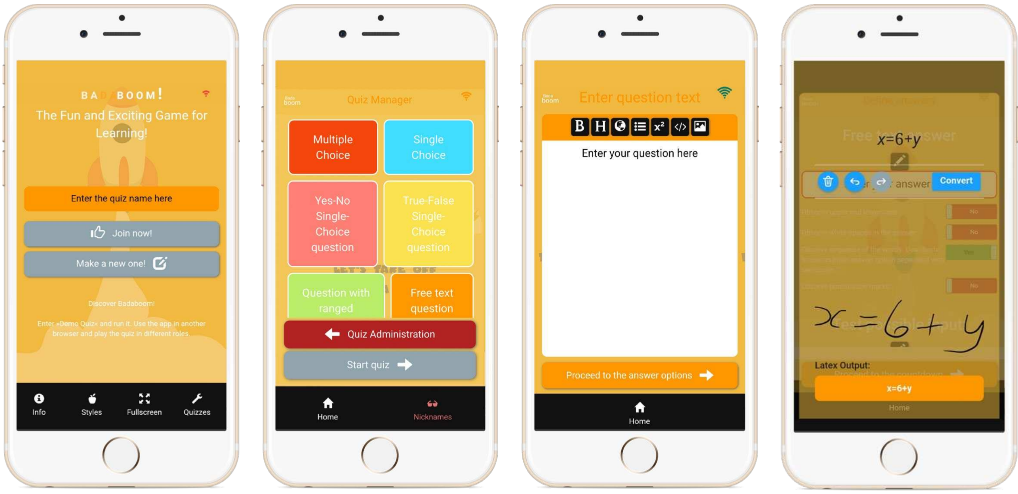

Figure 2: Badaboom User Interface (UI) with LaTex Equation Editor
Source: PALMS, n.d.

While past research in game-based learning has demonstrated the significance of immersion and flow on learners, they have not examined these two concepts in the general context of game-based classroom response systems. The Badaboom! game-based classroom response system offers a unique opportunity for students to effectively regulate their immersive and flow-oriented motivational strategies. Immersion requires focus and concentration in which the player is faced with immediate and solvable goals. Moreover, immersion in the game focuses on sensory cues that engage the player's mind via sensory stimulation, for example, through graphics and soundas well as the extent to how involved the player is in the gaming experience and what response is expected on the part of the player. In playing Badaboom!, students' responses are captured, analyzed, and displayed instantaneously. Students receive instant feedback on how they are performing and subsequently, they are able to gauge their progress in terms of their understanding of the course content.

Flow focuses on the cognitive elements of the gaming experience, focusing on the alignment between the challenge of a task and the skills of the player, and also encompasses the highest state of concentration and awareness, a sense of control and feedback on progress. In broad terms, challenge refers to players' perceptions that an activity compels them to perform to their fullest potential (Shroff and Vogel 2009). As such, players have a typical and customary level of task challenge they are willing and capable of handling. Furthermore, challenge involves a player's perceived ability to perform activities directed at achieving those goals (Shroff and Vogel 2009). The Badaboom! game-based classroom response system provides a challenge-based structure, which rewards the player by means of status through being on top of the ranking board. The different types of challenges within Badaboom! can be subdivided into three distinct types: difficulty and skill, mastery, and uncertainty.

Difficulty and Skill

The Badaboom! game-based classroom response system was developed to be both challenging and competitive and within the player's cognitive structure. This means that the player's perception of difficulty is what keeps the player immersed in the activity, subsequently allowing the player to conquer the challenge. Moreover, a player's perception of the challenge when immersed in the game should be equal to the perception of the player's skill levels and abilities (Shroff and Keyes 2017). Consequently, tasks where skill and challenge are not balanced, can lead to boredom or anxiety. For example, the game-based multiple choice task in Badaboom!, whereby players attempt to answer by selecting the correct lettered box that is associated with the correct answer, presents players with hidden information together with a sense of unpredictability and randomness. Hence, an intrinsic objective of game play is to subsequently make sense of that information. As such, players are able to display a willingness to initiate these difficult tasks, persist in the face of failure, and subsequently seek challenges that are neither too easy nor too difficult. In short, the player feels challenged when the task creates a certain amount of difficulty, thereby keeping the player involved in ongoing cycles of seeking and conquering challenges (Shroff and Narasipuram 2009).

Mastery

Mastery is a key component of both game players' experience and motivation. Mastery is based on both accuracy and speed, and is characteristic of the player's ability to control the game in respect to how the game unfolds and progression of the game in terms of quickness and speed. Players who believe in their abilities will spend more effort to master the game, whereas players who doubt their skills will be more disinclined to dedicate as much energy to playing. As a player's skills increase during the game, the difficulty level of the game increases continuously in order to preserve the balance between mastery and challenge. Mastery is typically rewarded either by a high score or progression to a higher level. For example, the gaming elements of Badaboom! allow the player to interact in different ways to overcome game-play challenges and experience a sense of mastery of the game. Moreover, as players progress through the game, the level of difficulty increases, thereby allowing players to learn and, most importantly, practice and develop their skills so as to master the game in due course. Hence, as players progress in the game the level of difficulty increases steadily, thereby increasing the players' skills and pace. It is this cognitive mastery in which players seek and conquer challenges that are optimal for their capacities (Shroff and Narasipuram 2009). Moreover, when they find challenges, players work to conquer them and they do so persistently (Shroff and Narasipuram 2009).

Uncertainty

Challenge can also arise as a result of a player's uncertainty regarding the other players' behaviours and a player's uncertainty of outcomes, strategy choices, and unpredictability. Challenge requires the task to be within a player's cognitive ability, meaning the the capacity of the player to perceive, reason, or use intuition. Players are challenged when they direct activities toward particular goals and where the achievement of those goals provides a degree of uncertainty in which neither success nor failure is guaranteed. Badaboom! has a unique feature that allows players to associate a level of confidence with each answer, so that their degree of certainty in answering can be assessed. For example, when answering a question, players can use a responsive slider control function (see Figure 3), which represents a range to indicate their degree of certainty that the answer they selected is, in fact, correct.

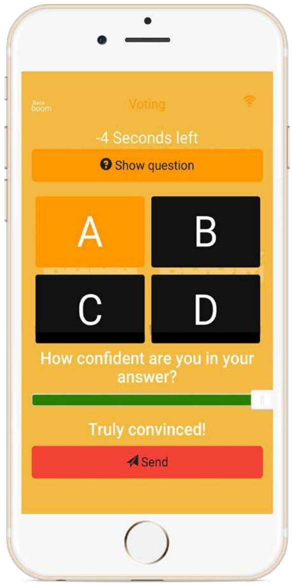

Figure 3: Badaboom! UI Illustrating a Responsive Slider Control Function to Indicate Players' Degree of Certainty
Source: PALMS, n.d.

On voting, players select the degree of confidence for the correct answer ranging from "guessing" (0%) to "truly convinced" (100%). The average value of confidence is displayed in the voting statistics. Hence, players can add to each answer an estimate of their degree of certainty. Moreover, with immediate feedback provided by means of a display indicating players' degree of certainty in answering a question, the instructor is able to gauge whether the concepts are properly understood and/or require further elaboration. This feature is particularly useful where the outcome is not always known and, subsequently, the tasks may present players with hidden information together with a sense of unpredictability and randomness. As such, players display a willingness to initiate difficult tasks and persist in the face of failure.

Discussion and Conclusion

In the field of education, digital game-based learning technologies are increasingly being used to form a comprehensive, perceptually stimulating, and learning-enhancing environment. Consequently, what the use of digital game-based learning technologies has brought about is a complete rethinking of today's learning strategies which are to date only partially understood. Game-based classroom response systems such as Badaboom! are designed to work to stimulate an individual learner's motivational disposition with the potential to evoke highly immersive and flow-oriented experiences. This example lends credence to the notion of immersion and flow, two significant concepts of the player experience that can occur during game play. Hence, one of the most important aspects of game-based technologies is for the game developer to create immersive and flow-oriented experiences that ignite players' cognitive and sensory curiosity and control. When players are immersed in a game, their focus is directed toward the game's objectives and the game world. Hence, the player is immersed when they experience a cognitive and emotional investment with the game. Similarly, flow is a state of optimal experience characterized by an optimized level of challenge. A game-based classroom response system like Badaboom! has the potential to support a player's immersion and optimal flow experience by subsequently engaging players in activities that are challenging but not too difficult. Moreover, the extent to which player's feel challenged in a game-based learning activity may depend, in part, upon the nature of the interactivity experienced by the players and by the virtual environment created by the technology itself (Shroff and Keyes 2017).

There is considerable potential for future research to further enhance our understanding of the immersion and flow in game-based learning contexts. For example, examining the influence of self-efficacy on immersion and flow in game-based learning contexts remains relatively unexplored and holds potential for future research. Other future research studies may provide us with much-needed insights and perspectives into how to create realistic gaming environments from a playability perspective that allows for immersion and flow to enhance the overall gaming experience. According to Kiili and Lainema (2010), playability is a significant factor that combines aspects of both flow and immersion. Moreover, future work could also examine antecedents of flow and immersion such optimal player experience, playability, and game dynamics.

This paper sets forth a conceptual framework for immersion and flow in digital game-based learning with a focus on providing a theoretical basis for future in-depth studies by understanding the impact of player immersion and flow in a game-based learning context. By providing a conceptual framework that illustrates the concepts of immersion and flow, this paper is a significant attempt to contribute and add to the extant knowledge of immersion and flow research in a digital game-based learning context. In light of the limited research on immersion and flow in digital game-based learning contexts, the conceptual framework presented in this paper may provide constructive insights and discussions for further advancing the literature and framework on immersion and flow in digital game-based learning contexts.

Acknowledgements

The authors would like to thank the University Grants Committee of the Hong Kong Special Administrative Region and the Hong Kong Polytechnic University (PolyU) for funding this project. This work is supported by the project funded by the University Grants Committee of the Hong Kong Special Administrative Region, entitled “Developing Active Learning Pedagogies and Mobile Applications in University STEM Education” (PolyU2/T&L/16-19), and is funded by the University Grants Committee of the Hong Kong Special Administrative Region with additional support from the Hong Kong Polytechnic University.

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Ubiquitous Learning: An International Journal
sets out to define an emerging field. Ubiquitous learning is a new educational paradigm made possible in part by the affordances of digital media.

Ubiquitous learning is a counterpart to the concept "ubiquitous computing," but one which seeks to put the needs and dynamics of learning ahead of the technologies that may support learning. The arrival of new technologies does not mean that learning has to change. Learning should only change for learning's sake. The key perspective of the journal is that our changing learning needs can be served by ubiquitous computing. In this spirit, the journal investigates the affordances for learning in the digital media, in school, and throughout everyday life.

Ubiquitous Learning: An International Journal is a peer-reviewed, scholarly journal.

ISSN 1835-9795