A DESIGN SCIENCE APPROACH TO GAMIFY EDUCATION: FROM GAMES TO PLATFORMS

Research in Progress

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Abstract

Recent research shows that gamification is a valuable tool to improve students' learning effectiveness. However, its application continues to be limited. Educators remain reluctant to use games due to factors like limited resources, game complexity, inadaptability to various learning-outcomes, weak student involvement, and difficulty to integrate in course structures. In this article we argue that, when purposefully designed, educational games can address those factors that hinder adoption. Accordingly, we identified seven design principles that, if satisfied, are expected to yield educational games that are useful to both educators and students. The principles accentuate the importance of designing educational platforms over which games can be created and played. Game platforms must (1) adapt to various educational purposes, (2) enable educators control over student engagement (switching on/off game features like rewards, personifications, etc.), (3) scale up/down to achieve the desired level of complexity, and (4) maintain student arousal by dynamically balancing the challenge level with skill level. To evaluate the design principles, we intend to design a business game platform with educators that reflect the seven proposed principles and evaluate it in class settings. If fruitful, this research will advance extant knowledge on learning strategies and specifically the design of educational games.

Keywords: Educational games, gamification, education, addiction, flow theory, design science.

1 Introduction

The gamification of business contexts has drawn considerable attention among practitioners in the recent years (Tarhini, Hone and Liu, 2014a, b). Gartner (2011) predicts that, by 2015, over 50 percent of organizations will gamify their innovation processes. In university classrooms, education has not yet been successfully gamified albeit evidence of their usefulness (Carolyn Yang and Chang 2013). A study shows that instructors avoid using games in the classroom due to their long learning curve, lack of user-friendliness, inflexibility in relation to course structures, and budgetary constraints (Baek 2008). Moreover, instructors often fear the negative effects of games, such as unhealthy competition between students, uncontrollable classroom behaviours and gaming addiction (Baek 2008). According to Joel Klein, the CEO of the education game company Amplify Learning, existing educational games are not designed to appeal to students resulting in a general lack of interest or willingness to invest time and effort (Warren 2014).

On the other hand, 97% of American teens invest time in computer games (Warren 2014). Some spend over 25 hours weekly to feed their gaming addiction (Cole and Griffiths 2007). Online multiplayer games are also ever more popular. Online games such as World of Warcraft has an active user base of over 10 million consumers and generates around $1 billion annually (Marchand and Hennig-Thurau 2013). Many of the computer games have addictive features that detain the players' attention. While the demand for IT professionals continues to be among the highest in North America (El-Masri and Addas 2014), *computer scientists* who are able to design games that highly engage users and satisfy

arousal are one of the top sought for careers (Heaven 2014). According to the VP of games at Amplify Learning Company, great games "have the capacity to keep kids engaged in intense, high-cognitive tasks for long periods of time" (Warren 2014). While some researchers consider addictive features on games harmful in nature (e.g., Barnes and Pressey 2014; Grüsser et al. 2006; Lemmens et al. 2009), others claim that it can be channelled in positive ways to encourage constructive behaviours such as learning (Hsu et al. 2014).

In this paper, we argue that educational games can be designed that address the factors described above hindering their use in educational setting. Accordingly, we seek the development and evaluation of a theory of design that is specific to educational games. We ask the following question: *What are the design principles of educational games that can address the reasons for the lack of adoption by educators in higher education?* A preliminary investigation led to the identification of seven design principles that are described in this paper. We will evaluate the principles by designing a prototype of an educational game platform that corresponds to the design principles specified and conduct experiments in classroom settings. If the design principles are proven to produce educational games that are superior to existing ones, we believe that this research will contribute to the field of pedagogical research. Specifically, it will provide a feasible mechanism that allows educators to design innovative learning tools (games). By completing the design science research cycles – which is to develop, demonstrate, and evaluate design theories – we also seek the creation of an artifact that can be useful in higher education. The paper is organized as follows. The next section introduces the relevant concepts and reviews the adoption barriers of educational games. Next, those hindering factors are analysed and the design principles that address them are proposed. In the following section, the validation plan is proposed. Finally, a conclusion is offered.

2 Gamification and Adoption Barriers

Recently, social science researchers have given great attention to the gamification phenomenon. According to the Web of Science database, the number of articles published on gamification increased from 6 articles in 2011 to 106 articles in 2014. For the most part, the interests of researchers and academics were directed to their use in business settings. Today's organization are developing and implementing games in order to improve work processes such as training, recruitment and marketing. Gamification – a new buzzword in information systems research – is defined as the use of gameplay mechanics for non-game applications (Bajdor and Dragolea 2011). It is intended to encourage users to compete with the ultimate goal of producing better results (Bajdor and Dragolea 2011). For instance, SAP Roadwarrior was developed by SAP as a game in order to teach their sales force about new products and prepare them to interact with customers (Herger 2012). Toyota uses the social computer game "Second Life" to setup virtual stores and simulate advertisement potentials (Kaplan and Haenlein 2009).

While abundant success stories on the application of gaming in organizational contexts were analysed and documented, gamifying the educational contexts has been limited. There have been some successful attempts to gamify education. For instance, ERPSim is an enterprise resource planning simulation game that was developed at HEC Montreal to teach business students the cross-functional decision making in enterprise-wide contexts (Cronan et al. 2011). The Game-based educational tool SimSE that was developed at University of California in Irvine to teach university students how to perform software engineering processes in virtual environments (Sadabadi 2014) won the best courseware award for its effectiveness. However, educators remain reluctant to include games as learning tools (Baek 2008; McFarlane et al. 2002) albeit evidence of their usefulness (Carolyn Yang and Chang 2013). One reason why gamification is successfully being implemented in the industry and not in education might relate to the degree of sophistication students demand from a game. According to Squire et al. (2003), students expect some basic feature from a game that educational games often do not include. Squire, along with other members of the Games-to-Teach research team, developed – through game design experiments – a set of educational game design principles that leverage existing technological capabil-

ities (Squire et al. 2003). Some of those design principles tap into the games ability to create a valued virtual identity through the inclusion of fantasy, narrative, and role-playing elements (Squire et al. 2003; Wideman et al. 2007).

While those design principles necessarily attract students, there are still a number of factors that hinder teachers' adoption of educational games in the classroom. These factors that make instructors unwilling to give educational games a chance in the classroom can be organized under five categories of barriers that relate to 1) resources, 2) readiness, 3) game flexibility, 4) usefulness, and 5) side effects (see table 1). The first category of barriers – resources – corresponds to the excessive time that instructors require to locate and adapt games to their needs as well as the costs required to purchase the games and set them up. Readiness barriers include the factors that relate to the instructor's abilities and knowledge to conduct the games with the amount of supporting material and guidance available. It also includes the factors that relate to the students' technical and computer capabilities to handle the games' complexity using the provided supporting material and instructors' guidance. Game flexibility barriers comprise the degrees of flexibility that the game design embeds to allow the instructor to adapt the game to the (a) course content and learning objectives, (b) course structure, (c) and student group formation. Indeed, flexibility has often been identified as a key feature of success (El-Masri 2009). The fourth category addresses the barriers that diminish the games' usefulness by rendering it too lucid and not educative enough, too educative and not playful thereby hindering engagement, or too buggy and ineffective. Lastly, the side effects category reflects the possible negative outcomes that instructors fear from gamifying learning such as increased students' addiction to games and excessive competition among them (more detail description can be found in table 1). In the following section, the five categories of barriers identified are scrutinized to determine the design principles of educational games that can help address them.

Category of Barriers	Factors	References
Resources	Time: The time required to locate, prepare, or adapt the games are too long.	Aljaraideh (2014), Baek (2008) Gros (2003), McFarlane et al. (2002).
	Cost: Games cost (including the computer devices and the internet connection) is too high.	Baek (2008) ; McFarlane et al. (2002).
Readiness	Level of student readiness: Students' ability to handle the level of complexity of games (technical and computer related); the alignment between supporting material and students' skills.	Aljaraideh (2014), Baek (2008), Lopez-Morteo et al. (2004).
	Level of instructor readiness: Instructors' ability to conduct the games; the alignment between supporting material and teachers notes and instructors' pedagogical skills.	Aljaraideh (2014), Baek (2008).
Game flexibility	Alignment with course content: Games that suit the required learning cannot be easily found. Game cannot be easily adapted to the learning objectives.	Baek (2008), Gros (2003), McFarlane et al. (2002).
	Alignment with course structure: Games are too long and cannot be adapted to the available time. Games cannot be adapted to the way instructors want to present course topics.	Baek (2008), McFarlane et al. (2002).
	Alignment with group structure: The number of players required to conduct the games cannot be modified.	McFarlane et al. (2002).

Usefulness	Level of learning: Games focus too much attention on ludic and stimulating elements rather than on educational goals.	Baek (2008), McFarlane et al. (2002).
	Level of engagement: Games focus solely on the educational goals and is too unappealing for the players resulting in low engagement and diminished learning.	Baek (2008).
	Game quality: Games can be defective and incomplete leading to wasting too much of instructors' and students' time and resulting in diminished learning.	Lopez-Morteo et al. (2004).
Side effects	Addiction: Students might form addictive behaviours from playing games.	Baek (2008).
	Excessive competition: Students might become obsessed with winning.	Baek (2008).

Table 1. Barrier factors that hinder the adoption of educational games as tools for learning by instructors.

3 Design Principles of Educational Games

Our analysis of the gaming industry shows that games are increasingly more successful in the entertainment and business contexts but not in education. In entertainment, the global video games revenues reached $81.8 billion dollars in 2012, five times higher than the global music revenues, higher than consumer book sales, and approaching movie revenues (Marchand and Hennig-Thurau 2013). In business, games are used by big companies such as SAP (Herger 2012) and Toyota (Kaplan and Haenlein 2009) to improve operational efficiency and effectiveness. Yet, barriers to adopt games in education as enumerated above still persist. Those hindering factors can be related to the characteristics of the games generated and used in education. Perhaps the creators of educational games, whether computerized or not, are not applying the appropriate principles when designing them.

In order to investigate the possibility that the hindering factors to adopt games in education could be related to inappropriate design principles, we turn to Design Science Research as the guiding research approach. According March and Smith (1995), the incomplete understanding of the environment in which a certain design artifact operates in could lead to its inability to attain its intended outcome. Accordingly, the objective of design science research is to intervene and improve existing artifacts by searching for the most appropriate design alternatives (El-Masri and Rivard 2012; Purao 2002; Sein et al. 2011). Design Science is "tough, analytic, partly formalizable, partly empirical, teachable doctrine." (Simon 1996, p.113). it formalizes the logic of design by prescribing statements of how artifacts "should become" (Pries-Heje and Baskerville 2008). The primary contribution of design science to knowledge is reflected in what the literature calls design principles which are rules that guide designers during their design of a certain *class* of artifacts (Hevner and Chatterjee 2010). The truthfulness of design principles can be evaluated using prototypes of the intended artifacts (Hevner and Chatterjee 2010).

3.1 Educational Games as Platforms

Accordingly, we followed a design science research methodology that is described by Peffers et al. (2007) to formulate the design principles of educational games that can address the hindering factors described by educators (see table 1) and at the same time stay faithful to their educational purpose. A closer scrutiny of the above barriers that the relevant literature highlights some dilemmas that educators face when integrating educational games as one of their learning tools. The first dilemma is the difficulty to find educational games that meet the educational needs of educators. Although, educators find benefits in games since they tend to engage students better and want to incorporate them into their

teaching tools, there exists no set of games that is comprehensive enough to contend with the abundant learning objectives that educators need to realize on a regular basis. Research stresses on the shortcoming in existing games that often do not satisfy the instructors' learning outcomes and are too rigid to be adapted (Baek 2008; Gros 2003; McFarlane et al. 2002). This can be attributed to the fact that educational games are often designed by educators or academic centers to achieve specific learning objectives in courses given in that institution. Additionally, although academic programs have a lot of courses and learning objectives in common, the anticipated level of learning vary depending on the institutions and course levels. When the educational game is computerized, it becomes even more difficult for adopters to modify its content, workflow, and level of complexity. Hence we propose:

> **Design Principle #1:** Educational games must be purposefully built on **game platforms** that can *adapt* to various educational purposes.

> **Design Principle #2:** Educational games must be purposefully built on **game platforms** that can *scale* to achieve the desired level of complexity.

A game platform that adapts to various educational purposes and scales to different levels of complexity allows educators to reuse it in multiple game scenarios in different context thus reducing the costs attached to continuously buying games. Since they can be repeatedly used, educators gain experience and increase their level of readiness each time they design or conduct a game thus reducing the amount of time they spend looking for games. Nevertheless, these platforms should also be configurable enough to allow educators to build new games or adapt games they previously created with the least amount of time required. Therefore our fourth principle is:

> **Design Principle #3:** Educational games platforms must be *highly configurable* to allow educators to design the workflow of the game relatively fast.

The adaptability of a game platform will help educators to purposefully design educational games that can attain the learning objectives they set within the constraints of time and group structures. On the other hand, the scalability of the game platform will helps educators design educational games that correspond to the required complexity and on par with students' ability to handle them. The platform must allow educators during the game design phase to choose the topic depth they want to achieve in terms of the number of concepts and the interactions among concepts.

3.2 PLATFORMS AS ENABLERS OF STUDENT ENGAGEMENT CONTROL

While game platforms that implement the design principle of adaptability and scalability could potentially resolves a number of the barriers for adoption as described above, they can amplify others. One factor that prevents educators from adopting games as an educational tool is that the available games can either be too playful and often ludic or too educational and potentially dull. When games are playful-centric, the students' behaviours become less controllable and little learning is achieved (Baek 2008; McFarlane et al. 2002). Students demonstrate addictive behaviours and the level of competition can reach unhealthy levels (Baek 2008). On the other hand, when the game does not exhibit playfulness, students get bored and stop engaging in its activities (ibid). The latter is especially true when educators repeatedly adapt the same game platforms to a multiplicity of games. Students can find it dull and reduce their engagement which diminishes learning.

The ability to balance between playfulness and education requires educational game platform design that allows educators to control the level of student engagement. In other words, educators must be able to lead the players (students) to reach a state of enjoyment in an activity without reaching a state of complete immersion in the game. There has been abundant research on attaining high task engagement; some of which is identified under the game addiction literature. Game addiction refers to a pathological usage of the game while high engagement is associated with a non-pathological usage that can be controlled by the user. (Charlton and Danforth 2007). Addicted game users constantly seek to resume their activity in order to relieve the sensation of euphoria felt while playing the game and to

avoid the unpleasant emotions caused by the cessation of the activity while highly engaged users pursue gaming activities in search of enjoyment (Charlton and Danforth 2007). Studies investigating gaming addiction have shown that some games embed features that can be addictive resulting in higher ranges of time investment (Grüsser et al. 2006). For instance, the internet in general and social media in specific are characterized by their ability to allow people to interact online (Grohol 1999).

Some of the game features that lead to high levels of engagement and possibly addiction relate to the choice of game character (or Avatar), aesthetics, interaction, ludic loops which are pleasurable feedback loops that stimulate repetitive behaviour, multi-users competitiveness or cooperation, rewards and reputation rankings (Chang and Chen 2008; Heaven 2014; Park and Chen 2007; Smahel et al. 2008). Notwithstanding the possible negative consequences of these game features and their contribution to game addiction, it is plausible to state that, if controlled, they can play a constructive role in engaging students in games without leading them to addiction. The degree of engagement in a certain activity lies on a continuum that ranges from no engagement to full emersion. Therefore, we assert that those features should not be hardcoded to the game itself but should be under the control of the educators so as to allow them to control the degree of student engagement. Respectively, we propose:

> **Design Principle #4:** Educational platforms must allow educators to enable and disable features of personification (avatar), game rewards, student reputation/ranking.
>
> **Design Principle #5:** Educational platforms must allow educators to create games at varying degrees of interaction between students (competitiveness, cooperation).
>
> **Design Principle #6:** Educational platforms must allow educators to define the level of ludic loops (pleasurable feedback loops between the game and the student).

3.3 GAME PLATFORMS AS ENABLERS OF STUDENT AROUSAL

One theory that can further help us to understand how high engagement in activities is attained and controlled is Flow Theory. According to Csikszentmihalyi (1997) the theory's main premise, there exists a state of flow that is realized when one reaches complete immersion in tasks and a sense timelessness. For the flow state to be achieved, three conditions have to be satisfied. First, the activity has to have clear goals which will allow one to focus and properly distribute one's efforts. Second, one needs to receive immediate and unambiguous feedback on one's performance to be able to make the adjustments to the varying demands of the task at hand. Instant and clear feedback reduces the set of options that one has and diminishes the risk that he will lose concentration and end the state of flow. Third, one has to believe that he possesses the skills to take up the challenge of the task. According to this theory, the level of challenge and the level of skills that one possesses also play a role in one's feelings during the experience. If the challenge is perceived as low, a very skilled individual will feel boredom whereas an unskilled individual will remain in a state of apathy. To trigger one's interest, the task has to represent a high enough challenge. When the challenge greatly overpasses one's abilities, anxiety is experienced. However, when one feels a sense of control in a highly challenging situation, s/he completely immerses in the task and experiences full enjoyment (see figure 1). The joy resulting from accomplishment constitutes the intrinsic motivation for oneself to reengage in the activity.

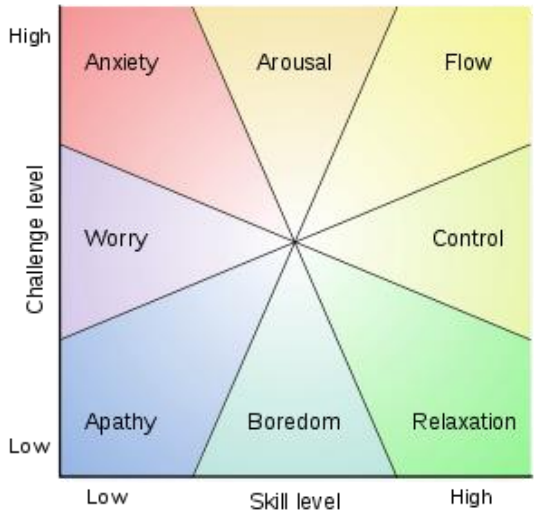

Figure 1. State of engagement in activities as defined by challenge and skill levels.

Games are generally seen as activities that have a high propensity to procure flow (Cowley et al. 2008; Csíkszentmihályi 1975). Indeed, games commonly embed features that satisfy the conditions to experience flow (Cowley et al. 2008). Since games can generate flow which, in turns, increases motivation, games have been perceived as powerful tools to foster learning (Paras and Bizzochi 2005). Researchers have argued that, if intentionally designed to provide a flow experience, educational games can better engage learners and reach their educational objectives (Kiili et al. 2012; Paras and Bizzochi 2005). According to Kiili et al. (2012), educational games should aim at constantly keeping the player in a flow state by balancing challenge and skills thereby avoiding feelings of boredom and anxiety.

However, maintaining a constant flow can be problematic for games destined to educate. Indeed, because flow is characterized by an absence of active awareness, no reflection occurs during flow experiences which implies that no learning is possible (Kiili et al. 2012; Paras and Bizzochi 2005). Emphasizing on the educational purpose, we argue that for educational games to remain faithful to their main goal, they should aim at constantly keeping the player in a state of **arousal**, not flow. By incrementally increasing the challenge in such a manner that the players' abilities are systematically maintained one grain below optimally handle the task, the players will remain engaged in the task and at the same time continue to learn. To this end we propose that:

> **Design Principle #7:** Educational platforms must keep students in a state of arousal by continuously maintaining the games' challenge levels one grain higher than the students' skill levels.

4 Validation Plan of the Proposed Design Principles

Design science research intends to improve existing artifacts by searching for the most appropriate design alternatives (Purao 2002). It formalizes the logic of design by prescribing statements of how artifacts "should become" (Pries-Heje and Baskerville 2008). By specifying and evaluating what the literature calls design principles or the rules that guide designers during their design of a certain *class* of artifacts (Hevner and Chatterjee 2010).

In this research, we follow a design science research methodology that consists of the three stages of design science research: 1) develop, 2) demonstrate, and 3) evaluate (Peffers et al. 2007). We plan to develop a prototype of an educational game platform that conforms to the proposed design principles. To design the prototype, we will work with the entrepreneurship program director at the college of business and economics at Qatar University in order to define the business related content that the

game platform must incorporate. The game will be used by students in marketing, finance, economics, management, etc. We will also build a number of games using Lego® Serious Play® that can be played on the platforms.

To evaluate the utility of the game platform, we will conduct a number of experiments. The Center for Entrepreneurship accepted to allow us the time and space to implement our game in their workshops (after verifying the usefulness of the games). We will conduct 6 to 10 experiments of 30 and 60 minutes each. The experiments will be of 3 different types:

1) Lecture based learning (no game).
2) Game-based learning that integrates the non-addictive engagement features as specified in the design principles.
3) Game-based learning that integrates all engagement features as specified in the design principles.

Students' knowledge and motivation to pursue their entrepreneurship project will be measured before and after the experiments. A short survey will be used to measure students' knowledge and motivation. The part of the survey that addresses the knowledge of the students before and after the experiment will help us measure the degree of learning that students achieved in lecture-based, game-based 1.0, and game-based 2.0 experiments. This will give us an indication of the utility of the game platform. Statistical discriminant analysis using SPSS will be performed on the data collected from the surveys to measure the approach that yielded the most optimal results.

5 Conclusion

Education is slowly moving from a lecture based approach towards a more experiential learning approach. Games can be beneficial to students as they can simulate a real-world environment and provide hands-on experience on the topics they are getting exposed to. However, educators are resisting adopting educational games because of the difficulties to find the proper experiential learning tools that can balance between student engagement, education, and resources.

Earlier work on the identification and evaluation of educational games' design principles (e.g., Cowley et al. 2011; Squire et al. 2003) underlined the features that can make the games appealing to students. However, those principles neither address the constraints that educators face when selecting the educational game to use nor do they solve the problems faced during implementation. Our study complements those efforts by identifying the principles that make educational games appealing to both educators and students. It examines the core subject matter in the IS discipline by proposing and evaluating the design future educational artifacts.

Moreover, this study addresses a practical problem that is the closes to us academics. According Benbasat and Zmud (1999), research that is stimulated by problems in practice tend to produce implementable implications. Indeed, this research is consistent with this stance as its outcome is a tool for educators to use. Our research advances design science by proposing design principles of future artifacts. We also produced implementable and practical implications by demonstrating and evaluating those principles. Taking an action research approach will allow us to work closely with educators in order to validate the proposed design principles and assess the artifact's usefulness in practice.

Lastly, this study is in line with the recent call to address complex organizational problems using an interdisciplinary approach. We combine knowledge from computer science (features that lead to online game addiction), social science (lack of adoption by educators), and design science to define principles of design of educational platform.

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