The Effect of Gamification in Learning Computer Sciences: A Critical Analysis

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Abstract
The intention of these paper is to rigorously examine the effect of gamification in learning computer science using a critically literature review analysis as method. Different literature reviews indicated the gamification is one of the most important elements of learning computing technology in this century. However, this has come alone with number of challenges and effect from various context. Some of the challenges from the critical review conducted by this paper include resistances to changes lack of will to move traditional and conventional learning methods to the modern once. This paper therefore recommended an orientation approach from both teachers and the learners to understand the importance and the advantages accepting modern innovation such as gamification in teaching and learning computer science.

Key words:
Gamification, Computer, Learning, Effect, Analysis.

1. Introduction

Teaching computer science programming to students and children of younger age is quite a challenging task (Kalelioglu, 2015). Developing motivation and ways of absolute engagement of the students could help them easily understand the introductory computer programming language and comprehend how computer works and improve their problem solving abilities. Thus, for students to learn computer programming in a funny way it is highly important that their achievement, motivation and engagement is develop in children right from the younger age (Kalelioglu, 2015).

According to Zhang et al. (2014), most of these challenges is drastically reduced for students find it very comfortable learning programming with through visual presentation such as the use of Scratch programming tool. Scratch is one of the most common programming tool used in teaching computer sciences subjects and especially introductory programming education at secondary and intermediate school levels. Scratch as a visual programming tool is believe to facilitate higher order thinking thus support the development of student's achievement, motivation and engagement (Salahli M.A. et al. (2017). Scratch is designed with an innovative interface which provides social context for students to create and share computer models and also learn from models create by others (Resnik et al, 2009). The social context might benefit the students developed themselves in many ways.

The poor performance of students in these programming subjects is always a hot topic during educational gathering held on the country; it is always mentioned that students' performances differ from a school to another and between different regions of the country. With this regards, this study seek to investigate the the Effects of Gamification Features on Students' Achievement, Motivation and Engagement in Learning Scratch programming Language which is also part of the computing subject.

2. Background

Gamification involves adding game features into a non-gaming circumstances, one of the most common circumstances where gamification features are applied is education which embraces teaching and learning activities (Caponetto, Earp, Ott, 2014). The use of gamification features in education is mainly to upsurge and enhance students' engagement and motivation towards learning programming (Gede, et al., 2018).

In the past few decades researchers have increasingly developed interest in assessing the use of gamification features (Nacke & Deterding, 2017; Looyestyn et al., 2017; Seaborn & Fels, 2015). The use of gamification features in general is aimed at implementing game elements such as points, badges, and leader boards to enhance people's motivation to perform better in order to achieve a specific objectives. This objective vary significantly with the aim of the game designer and the situation within which the design will be applied (Christian and Conrad, 2019). Barata et al., (2017) stated that in the educational field the use of gamification features may be targeted at improving student's motivation to be engaged in the learning process in the class

Scratch was developed as a Lifelong Kindergarten Group at the Massachusetts Institute of Technology Media Laboratory. It was developed as a visual programming tool that enables the creation of stories; art projects animations as so on (Kaucic, & Asic, 2011). Scratch was

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design and developed to support teaching and learning and also allow a wide range of activities that appeal to young learners of different ages and background (Kaucic, & Asic, 2011). Scratch offers sample advantages to computer science students and to the programming learners, such as learning new mathematical and computational concepts as well as understanding design process thoroughly (Kereki, 2008). From the teachers and educators perspective, scratch allow educators to reduce the cognitive load encountered by programming learners (8) Garner, S. (2009

Scratch has been used more than any other media creation tool (Kaucic, & Asic, 2011). Also reported the experimental use of scratch for Computer Science and Vocational students in Uruguay. The studies of Garner, S. (2009 also reported how scratch was extensively used in the early stage of introductory programming courses which guide students on data usage, control structures and use of algorithm for business system. Programming with Scratch take the form of script and control sprites, the scripts represent the program components, which are created by dragging and dropping blocks (Meerbaum-Salant 2013).

Gamification features are meant to influence student's desires and aspiration for socializing, learning, mastery, competition, achievement, status, self-expression, altruism, or closure, or simply their response to the framing of a situation as game or play (Lieberoth, 2015). Early gamification strategies use rewards for players who accomplish desired tasks or competition to engage players, some of these types of rewards include point's achievement badges or levels, the filling of a progress bar, or providing the user with virtual currency (Hamari & Eranti, 2011). Making the rewards for accomplishing tasks visible to other players or providing leader boards are ways of encouraging players to compete. So the usage of the gamification features will significantly effects on the motivation of the students to learn the "Scratch" programming language and enhance their achievement records and consequence potential significantly effect on the Self-efficacy is expected. Based on this propositional assertion, this research is aimed at investigating the effects of gamification features on students' achievement, motivation and engagement in learning scratch programming language.

Moreover, there has been growing published research since 2000 about the use of gamification in education (Ritzhaupt, Poling, Frey, & Johnson, 2014). The sharp growth in gamification development has encouraged researchers and educators to integrate video games into different pedagogical areas. The effectiveness of using these games in school for educational purposes has also become a common topic in the field of educational technology and a potential means for personalized and blended learning environments (Thompson, 2015). This topic has been discussed from many perspectives such as performance, thinking, and behavior (Miller, 2008). It is a commonly held view that gamification can be used as a type of reward for students completing their work (Miller, 2008). Therefore, the use of gamification has shifted from being merely a form of entertainment to playing an important role in visual and technological literacies (Clark & Ernst, 2009). Gamification increase students' awareness and consciousness. It is evident that gamification play a central role in increasing students' intelligence quotients (IQ; Miller, 2008). Also, gamification can enhance other skills such as movement, social skills, visual abilities, and collaboration (Clark & Ernst, 2009; Miller, 2008). Findings from more studies suggest gamification usage can improve technical, linguistic, dynamic, cognitive, social, and collaborative work skills of students (Adkins, 2014; Marin Diaz & Martin-Parraga, 2014). Many researchers also believe gamification can be effective tools for learning (Miller, 2008). The gamification environment impacts the current generation of learners and researchers have noted how it is changing the ways in which students think and learn (Howard, Morgan, & Ellis, 2006). Players' social skills can also be enhanced by playing video games (Khoo, 2012).

3. The Challenges and the Effects

Recent research findings have vindicated that there are evidences of high poor performance in introductory computer science and programming subjects in Saudi Arabia which has been a subject of debate in most educational conferences in the country (Alakeel, 2015). It has been observed that, challenges and difficulties faced by programming teachers, students and independent learners is an issue of universal concern that affects academic performance of computer science and engineering students (Robins, Rountree, & Rountree, 2003). It is obvious that students considered programming as difficult task (Awasekar, 2013). Teaching programming language by the teachers as well as learning the real programming concept is not an easy task (Rajala et al., 2008). Previous studies reported issues faced by students in learning programming language; in the studies of McCracken et al., (2001) they reported that writing program code is the major challenge faced by students in computer science and engineering. Difficulty in reading the tracing skills among students was reported by Lister et al., (2004), whereas problem of software designing among students was mentioned by (Tenenberg et al., 2005).

Learning computer programming is one of the main requirements of many educational study plans in higher education (Bereiter & Ng 1991). Similarly, according to (Ali 2015; Evans & Simkin, 1989) research has shown

that many students face difficulties acquiring reasonable programming skills during their first year of school, and that learning computer programming is very complicated for many students at the first year of school Byrne & Lyons (1989).

Computer programming is difficult because students struggle to capture the required abstract concepts that are necessary to a program construction. The main source of difficulty does not appear to be the syntax or understanding of concepts but rather basic program's planning Davy & Jenkins, (1999), similarly, research shows that introductory programming courses have a relatively high fail rate. For example, Hagan in Dijkstra, (1989), states that programming was considered to be the most difficult and least interesting subject by most first-year students in all computing courses. Additionally, many institutes report dropout rates of 20-40 percent. Crawford, & Boese (2006), because of the importance of computer programming and the difficulties faced by the students, this topic has been investigated by many authors, e.g, Eckerdal, McCartney, Moström, Ratcliffe, & Zander, (2006); wikipedia.org/wiki/Saudi Arabia.

Computer language programming skills are very important in computer related fields of studies. Most of the students are required to take an introductory programming course and the basics of it. In high education in fact, programming is an academic discipline. Furthermore, programming is a skill requiring novice programmers to utilize multiple types of learning simultaneously (Bereiter & Ng, 1991).

Similarly, many programmers lack the knowledge and skills of programming experts. The knowledge of programming language tends to be context specific rather than general Byrne & Gerry (2001) have concluded that programming language are limited to surface and superficially organized knowledge, lack detailed mental models, fail to apply relevant knowledge, and approach programming ''line by line'' rather than using meaningful program ''chunks'' or structures. Novices spend little time in planning and testing code, and try to correct their programs with small local fixes Edsger & Dijkstra (1989). The computer programming learning is very complicated for many students at both secondary and university level Evans & Mark (1989) Computer programming is not difficult only because of the abstract concepts, but also students have problems in different issues related to program construction.

Form the teacher's aspects, the difficulties faced by the educators in teaching introductory computer science subjects and programming language raised a lot questions. The kingdom of Saudi Arabia is not isolated in terms of these questions. In order to explore the issues and properly understand the scope of the research problem a pre-pilot study was carried out by the researcher. Eight computer science teachers of the third (3rd) intermediate students in Saudi Arabia were interviewed through an interview protocol instrument develop by the researcher. The interview questions mainly focused on the challenges and difficulties faced by students in computer science subjects, introductory programming classes using Scratch and related children-friendly programming tools.

Gamification features would help students to develop self-determination and motivation to learn programming knowledge especially with Scratch programming. In order to investigate the effect of gamification features towards learning Scratch programming this study is designed use experimental and control groups by applying pre-test and post-test to examine the level of motivation at each stage of learning Scratch. In addition, the researcher will test the learning progress achievement of the students at the end of semester so as to compare between the two groups. In order to propose and recommend possible remedy to the issues raised, this study is intended to address the following research objectives;

4. Teaching Computer Science and ICT

Motivating and supporting students to use computer technology as well learning computer programming and to retrieve information is necessary to fully engage the students in learning activities (Samarkandi, 2011). Ayoub et al. (1998) further stated that such motivation allow the students to develop personal confidence and an impressed perception generally on computer science and technology.

Educational policy review occurs every five years in the kingdom of Saudi Arabia. During the fourth educational development plan (1985 to 1990) a bold decision was taken which leads establishment of General Administration for Educational Technology (GAET). This was the gate way for introducing technology in Saudi educational system and development especially the various institution of higher learning across the kingdom (Samarkandi, 2011). Another milestone achieved through this plan was the introduction and integration of teaching computer science subjects into secondary schools, colleges and universities. This curricular were generally introduced to integrate computer learning to all level of education in Saudi institution of higher learning. The curricular required that, students should register and take two hours credit in introductory computer, three credit hours of basic programming language, as well as three credit hours of information system and computing (Moshaikeh, 1992; Samarkandi, 2011)

Saudi Arabia is moving along with the trends of 21st century teaching and learning objectives as such the ministry of higher education is working towards integrating advance technological changes for the betterment of the students learning performances.

5. Self-Determination Theory (SDT)

The most commonly used theory for exploring and understanding how gamification could enhance motivation is the self-determination theory (SDT) and its associated sub-theories. In accordance with the concept of Self-determination theory, human motivation is consider as either intrinsic motivation or extrinsic motivation, because it depends on the either the activity is carried out for the sake of the activity itself or for the accomplishment of other external activities (Jonna, and Juho, 2019). Furthermore, Elisa et at., (2017) posited that self-determination theory (SDT) has clearly differentiate two major forms of human behaviour; where extrinsic behaviour denotes performing an activity mainly due to discrete outcome for instance pressure, or intrinsic kind of rewards be it monetary or through verbal feedback like to praise someone. Elisa et at., (2017) maintained that intrinsic motivational behaviour is the pursuit of an activity or one's interest.

According to Deci & Ryan, (2000), intrinsic motivation is believe to be to improving human motivational need for capability, competency, self-sufficiency, and understanding, and empathy. In particular competency is involves feeling of understanding and ability to beat the challenge at hand; self-sufficiency or autonomy refers to the ability to select what particular challenge to handle at a moment, and empathy is the knowledge of reasoning and reception (Deci & Ryan, 2000). Researcher believe that, all these are categorized as highly intrinsically motivational behaviour and are proven to be satisfied by playing games or using gamification features (Ryan et al., 2006; Rigby & Ryan, 2011). Using gamification features or directly playing game is known to be an intentional or voluntary behavioural action, usually perform at personal own encouragement and urging thus it is a behaviour that influences self-sufficiency. In addition, using gamification features is characterised with facing and tackling challenges that the player of the game could adjust to the optimum level, in fact this is one of the fundamental elements of performing game (Deterding, 2015). Therefore, the use of gamification features in either learning programming or playing game usually provide the user or player with experience of capability and competency to effectively tackles challenges encountered at every stage (Huang, Cheng, Huang, & Teng, 2018).

6. Motivational Model for ARCS by Keller

Motivation as a word was derived from the Latin verb "movere" meaning to set into motion. Motivation is what makes person to be successful, allow the person to keep on moving and attainment of further success (Supakit and Nicholas, 2000).

Stimulating and sustaining students' motivation has always been a great challenge to teachers, educators and tutors generally due to difficulties in identifying the most reliable means of inducing motivation to students. In an attempts to propose a lasting solution to this difficulties, ARCS was presented as a reliable approach which provides a comprehensive guidelines for assessing and analysing motivational characteristics of students and learners and then provides basis for motivational strategies based on the analysis conducted (Keller, 2000).

The ARCS stand for Attention, Relevance, Confidence, and Satisfaction also known as Keller' ARCS Model of motivation which was developed and introduced in the early 1980s by John Keller. The ARCS model is a combination of various motivational theories and characteristics which is subdivided into four major categories namely (i) Attention (ii) Relevance (iii) Confidence and (iv) Satisfaction. The abbreviation of the first letter from each word formed the acronym "ARCS". The four subdivided categories are considered as the core elements necessary for a student to be fully motivated (Keller, 2000). ARCS provides basis for combining the various theories, concepts, approaches, as well as tactics that relate directly to motivation to learn what is been taught in classroom (Keller, 1987). ARCS model was methodically developed from keller's theories of motivation, performance, and instructional influence around 1970s.

Keller's theoretical model of motivation, performance, and instructional influence is a macro theory that describes a network of the relationships of personal and environmental characteristics on effort, performance, and consequences. More specifically, in a motivational context, it assumes that effort is a consequence of motives or values, and of expectancy for success. Reinforcement serves to confirm or deny expectations. This theory is based upon a synthesis of many areas of research that pertain to human motivation, and its purpose is to help answer questions about how to design motivational strategies into instruction that will stimulate or sustain learners' motivation to learn. In other words, the purpose of this theory is to identify major categories of variables of individual behaviours and of instructional design that are related to individual effort (motivation) and performance (Supakit and Nicholas, 2000).

The theory assimilates a wide aspects of certain motivational concepts: not only expectancy-value theory, attribution theory, self-efficacy theory, learned helplessness, social learning theory, environmental theories, humanistic theories, aspects of attitude theory, and decision theory, but also the effect of reinforcement on motivation as well as cognitive evaluation and equity theory as the foundation of the theory to explain individual motivational tendencies. The theory of motivation, performance, and instructional influence also

distinguishes between three types of influence of instructional design (i.e., motivational design and management, learning design and management, reinforcement-contingency design and management). The assumption is that any instructional event, whether it is an educator in a classroom or a module on a microcomputer, will have these three influences; and the task of instructional design is to understand and control them (Supakit and Nicholas, 2000).

The ARCS model is a systematic means of improving the motivational appeal of instructional materials, of educator behaviours, and of the way in which lessons or modules and courses are designed (Keller, 1983).

6.1 Attention (A)

During teaching or classroom lesson, the topic been thought most gain the student's attention. This can be achieve in many ways for instance the teacher can make some unexpected actions such as loud whistle; the teacher can also presents emotionally inspiring problems that could lead to deeper inquisitiveness while the class session is ongoing; as well the teacher may apply the concept of variation that also help to catch attention of students since students may tends to have a kind of variety and eventually they lose attention if the teaching strategy does not change over time (Keller, 2000).

6.2 Relevance (R)

Relevance is another basic requirement needed to fully motivate an individual. After getting attention of the learner there is need for the contents of what is been taught to be relevance to the learners. Keller (2000), also argued that even if curiosity of the student is stimulated, motivation is lost once the contents does not seems to be relevant to the student. Relevance in learning is obtained from the combination of the content of what is been taught and it's important to the learner in addition to the learners' interests and style of learning.

6.3 Confidence (C)

Confidence is the third core element or condition of inducing motivation to student. Confidence is attained by guiding the students to build positive anticipation of success in their mind. Students usually are characterised with low confidence because they lack understanding of what is expected of them (Keller, 2000). Teacher as well as the guidance and counselling units could easily build confidence in the students by making the core learning objectives clear and providing examples of acceptable achievements. Once the performance of the students is improve i.e. achieving success which is believe to improve the students' confidence. If the student believes that success was due to external factors such as luck, lack of challenge, or decisions of other people, then confidence in one's skills is not likely to increase

6.4 Satisfaction (S)

Satisfaction as a core element required for building motivation amongst students which is refer to as positive feelings of students' achievements and knowledge gained during the learning process. It is a situation where student's obtains recognition and confirmation of success which further enhance their motivation of satisfaction while believing they have been treated justly. A system of reward or given out awards to the students can improve satisfaction these could be either substantive or symbolic such as grading system for subjects, privileges, award of certificates, or some monetary gift (Keller, 2000).

(a) Constructivism Learning Theory and Learning Programming Language

Many previous research have posited that adoption of constructivism concept for learning programming is posited to improve learning outcome by facilitating collaboration, communication, interaction, knowledge construction and sharing, as well as improvement of problem solving skills amongst students (Schreurs, and Al-huneidi, (2011). Hadjerrouit, (2005) presented another similar research titled "Constructivism as guiding philosophy for software engineering education". It is a pedagogical approach based on a constructivism mainly for teaching the core object-oriented concepts for students. Findings of Hadjerrouit, (2005) proved that by understanding the concepts of programming coding there is every likelihood for students to improve their problem solving skills. Beynon, (2009) investigated constructivist computer science education reconstructed, from the perspective of innovation in teaching and learning in information and computer sciences. The research was based on three case studies on how real life date can be used from constructivism to teach the sorting algorithms, solve puzzles and recognize groups from their multiplication tables.

According to (Azliza, Md Yazid, and Mohd, 2012), applying constructivism learning in teaching block code programming is termed the most powerful concept to improving student's learning interest, creativity and learning skills as well as problem solving skills Azlina et al., (2012), further stressed that, modern day advance technology used in teaching programming are very supportive and resourcefully collaborate in building constructivism learning environment. Therefore, programming teachers ought to use effective methods to motivate students in learning. Therefore, it has become obvious that constructivism has been applied, adopted and accepted by many scholars across both developed and developing countries at modern teaching practice like Classroom Teaching Mode, Individualized Learning

Mode, Network Classroom Mode, Distance Education Mode and Virtual Reality Mode.

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