Optimizing Gamification in Learning Solar System for Primary School

Open Access

Mohd Nabil Zulehmay[1,*], Muna Liyana Mohamad Tarmizi[2], Nurul Najwa Abdul Rahid[1], Anis Afiqah Sharip[1], Norfarhana Fadila Mohd Zaki[2], Nur Farahin Johari[1]

[1] Faculty of Computer Science, Universiti Teknologi MARA Melaka, Malaysia
[2] Academy of Language Studies, Universiti Teknologi MARA Shah Alam, Malaysia

ABSTRACT

Astronomy is one of the oldest branches of scientific study in the world. Today, astronomy has been taught as early as in the elementary school. In this study, we narrow down from the broad area of astronomy to the solar system topic, developed a game-based learning and test it's engagement in learning this topic. A preliminary study has found that students in primary school are facing several problems in grasping the solar system topic. High intellectual demand is one of the main factors that holding these students back to perform on this subject. They are also unable to provide a scientifically correct explanation of the concepts given in the school syllabus. The current research proposed gamification concept as an approach in teaching the students about the solar system. The game was developed using the GDLC methodology which proposed the adequate phase and criteria to be considered for the development of quality games. Several students who undergone this subject were selected to be the focus group for this research. A total of 14 items in GEQ was adapted to measure the engagement of the students towards the gameplay. The result indicates that gamification can provide engagement to the student in learning the solar system.

Keywords:
Gamification; game-based learning; solar system

1. Introduction

Students start to explore astronomy as early as in the primary school. Among the topics include solar system and phenomena surrounding the earth. In Malaysia, these topics are taught to fourth and fifth-grade students. Although they are just on the superficial level, they are still rather abstract in perspective and difficult for children to comprehend without proper assistance [8]. According to Miranda [11], students were unable to meet the high intellectual and attitudinal of astronomy. Danaia and McKinnon [3] stated that students were unable to provide scientifically correct explanation on astronomy concepts.

There are tremendous research on gamification that can help children to learn the basic concept in education. However, there are also arguments on the ability of game as an alternative to the traditional instructional material as it is commonly used for entertainment and possibly will distract students' attention. The game has been something that does not usually associated with educational activities. However, gamification – which utilizes the concept of game-based learning is a neologism

---

* *Corresponding author.*
E-mail address: Mohd Nabil Zulehmay (nabilz@uitm.edu.my)

that is coined in early 2013 which was used to support teaching and learning [13], and it has gained popularity in the recent years. Introduction of gaming in education is something that indeed is revolutionary and exciting for today's generation as we live in the era of ICT and the Internet of Things.

This research attempts to optimize gamification concept in the learning atmosphere. The aim of this study is to facilitate engagement in learning the solar system by using game-based learning approach. The student will unintentionally learn the solar system by playing this game. Therefore, the engagement on learning activity which aims to be stricken on this project will be realized.

2. Literature Review

The subject of astronomy has been proven to be quite challenging for students. Misconception in learning this subject is common among students, especially at a young age. Research by Dahsah *et al.*, [2]; Danaia and McKinnon [3]; Türkmen [17] found that there are misconceptions among the fifth-grader regarding some basic astronomy concepts such as day and night cycle, size and distance of earth, moon, and the sun measurement.

Astronomy subject has been considered important in human daily life. It is the center of human's life, guiding us in measuring time to form calendars, and understand daily meteorological events to long-term climate changes [8]. Astronomy deals with some important subjects such as advanced mathematics, science, and technology [12].

Solar System

Solar system has been included as one of the topics in astronomy subject. This topic is considered as a fundamental in the astronomy concept that will open up the understanding on how planets orbit the sun, rotation of the planet and moon that orbit the planets. The solar system consists of the sun, stars, eight planets, several dwarf planets, dozens of satellites, millions of asteroids and trans-Neptunian object, including comets and meteoroids [6].

Digital Game-Based Learning - Gamification

Digital game-based learning harness the concept of gamification to suit with the educational activity. Perrotta *et al.*, [13] defined digital game-based learning as video game used to support learning and teaching. The effectiveness of a game to the learning environment is due to its content, the interactivity between learners and the media that is delivered during gameplay, but not because of what the game is [18]. The game is a good learning material because it promotes engagement for learners [10]. According to Kiili [7], for maximum engagement, players need to be given challenges matching to their current skill level. This hands the word "leveling system" and "challenge and opponent" in a game design.

Interactivity is one of the main features in gamification. Research by Kapp [5] indicates that the level of interactivity within the environment is what drives learning. The interactivity in gameplay can potentially help learners to solidify their chance to gain knowledge.

Gamification in Learning Solar System

There are several studies on the application of technology in learning astronomy such as by using augmented reality, and also 3D modeling [4]. In addition, technology does have an impact in either increasing their achievement or attitude towards learning [9]. This paper focuses on a small portion

of the various topics of astronomy which is the solar system. The game is designed based on exploration origin from the genre adventure in game design. The adventure game is designed to help the learner to explore and experience the content first hand. Therefore, teaching and learning process indirectly occurs.

The review of the relevant literature found that gamification is capable to insert engagement in learning and teaching. Next, methodological issues will be briefly explained to gain understanding on the design phase.

3. Research Methodology

Game development life cycle by Ramadan and Widyani [14] is used for development of solar system exploration game. This method has been chosen as it proposes adequate phase and criteria to be considered in order to develop a quality game design. There are six steps to comply in GDLC namely; initiation, pre-production, production, testing, beta, and release. Figure 1 summarizes the flow of GDLC.
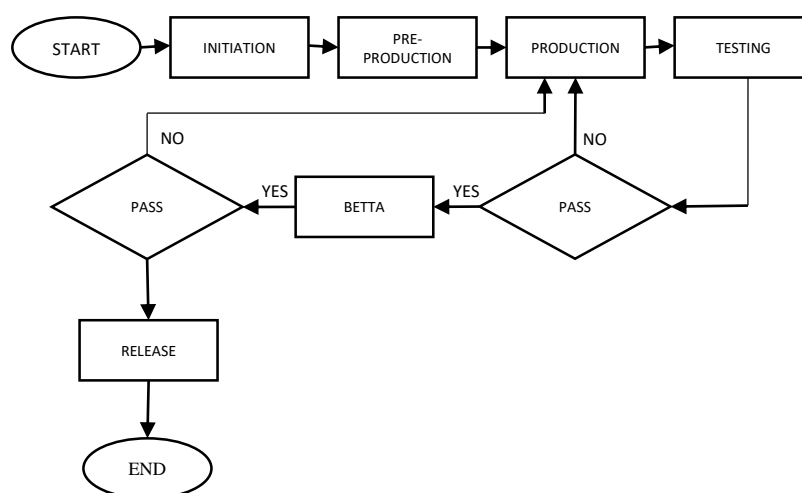

Fig. 1. Game Development Life Cycle [14]

All the game requirements, genres, rules, procedures, and structures were decided during this cycle. Testing was also carried out with two requirements, internal testing and beta testing before the game was released to the audience.

4. Analysis and Discussion

The survey was conducted to 26 participants in standard 5 which is 11 years old who undergo the subject of astronomy in school. The main objective of this study is to measure the engagement of the students towards the game developed. The questionnaire was adopted from Brockmyer et al. (2009), specifically designed to measure game engagement (Game Engagement Questionnaire – GEQ). There are 19 items in total listed in the instrument of GEQ. However, only 14 are considered suitable the most for this project. Below is the GEQ items (Figure 2).

Game Engagement Questionnaire (GEQ) items.	
1	I lose track of time
2	Things seem to happen automatically
3	I feel different
4	I feel scared
5	The game feels real
6	If someone talks to me, I don't hear them
7	I get wound up
8	Time seems to kind of stand still or stop
9	I feel spaced out
10	I don't answer when someone talks to me
11	I can't tell that I'm getting tired
12	Playing seems automatic
13	My thoughts go fast
14	I lose track of where I am
15	I play without thinking about how to play
16	Playing makes me feel calm
17	I play longer than I meant to
18	I really get into the game
19	I feel like I just can't stop playing

Fig. 2. The 19 items of GEQ by Brockmyer *et al.,* [1].

The following section covers the result from the evaluation obtained from the respondents. 5 point of a Likert scale was used to indicate the level of agreeability of the question or statement in the questionnaire survey. In this paper, only 5 surveys that best suited with the engagement factors are presented.
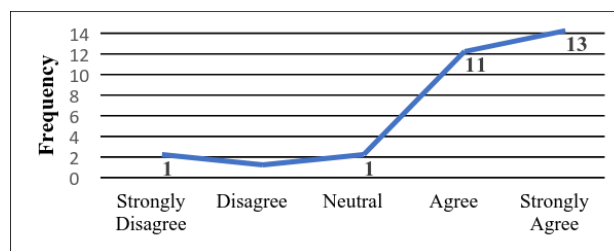

Fig. 3. Result of the survey for - I lose track of time while playing this game

Figure 3 presents the result of question 1 in GEQ. Most of the respondents agree that they lost track of time while playing the game. They are targeting on certain duration before starting the game and end up playing longer than they expected. This means the game has successfully made the players become immersed with it.
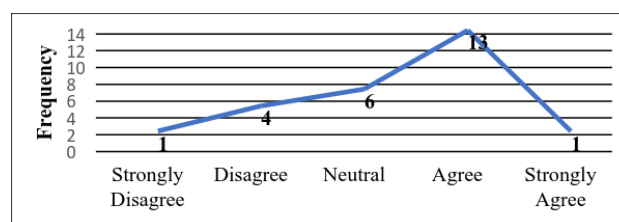

Fig. 4. Result for survey of – I play longer than I meant to

Figure 4 shows the response for the statement "I play longer than I meant to". 13 respondents which is the highest answer recorded agree to this statement. This game is capable to make the respondents play for a long period of time which manifest the engagement activity while playing the game. We also implement direct observation while the user plays the game. It was quite hard for

most of the respondents to stop playing before they completed the mission. They would not easily abandon the game while playing it. Most of them are immersed in the game. The respondents also begged to continue with the "mission" even though the researcher requested them to stop playing.
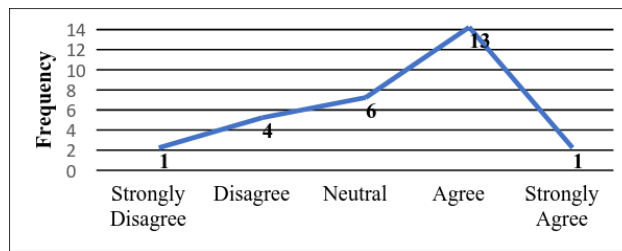

Fig. 5. I really get into the game

The total of 13 out of 26 students agree with the statement that they are really getting into the game. This indicates the respondents do engage with the games.
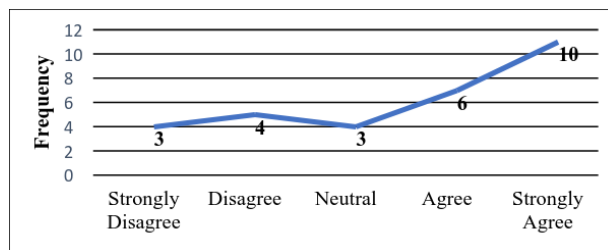

Fig. 6. I feel like I just can't stop playing

Figure 6 shows graphical information on the statement "I feel like I just can't stop playing". The result shows that 10 out of 26 respondents strongly agree with the statement. Only 7 in total choose to disagree and strongly disagree. This probably due to the prior knowledge they have about the subject so they are able to complete the game with very limited challenge faced.
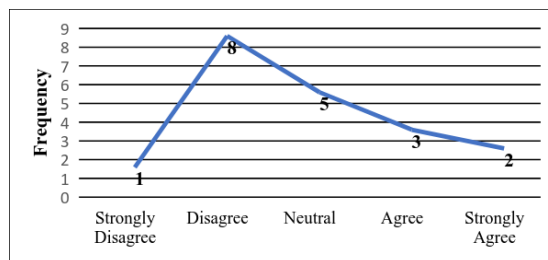

Fig. 7. If someone talk to me, I hear them

This statement changed from the existing GEQ to reduce negative statement in the questionnaire survey. The statement shows in Figure 7 – if someone talks to me, I hear them, manifest one of the engagement criteria towards respondents. 1 respondent said he strongly disagrees and 8 respondents in total answered they disagree with the statement. This means they are really into the game without realizing what is happening in their surroundings. Meanwhile, 2 respondents answer they strongly agree and 3 respondents answer they agree with the statement. It is normal to have a different level of sensitivity among human being.

5. Conclusion

A solar system exploratory game can provide engagement to the students while playing the game and unintentionally the student will get the basic concept of the topics covered in there. The main objective of this study which to embed the engagement to the learning process is considered a success. Most of the results present in this paper has achieved the desired outcome. Majority of the respondents manifest the engagement with the game developed. Gamification is in no doubt, can provide immersive teaching and learning process. However, the development of game-based learning must have a certain standard, procedure or guideline to ensure the quality. GDLC is one of the game design structures that is good to comply. Evaluation of the game needs to be conducted to improve the quality of the game designed because it is used for learning based purposes and it must also reach the main target which to deliver information.

References

[1] Brockmyer, Jeanne H., Christine M. Fox, Kathleen A. Curtiss, Evan McBroom, Kimberly M. Burkhart, and Jacquelyn N. Pidruzny. "The development of the Game Engagement Questionnaire: A measure of engagement in video game-playing." *Journal of Experimental Social Psychology* 45, no. 4 (2009): 624-634.

[2] Dahsah, Chanyah, Nason Phonphok, Chaninan Pruekpramool, Theerapong Sangpradit, and Jaturong Sukonthachat. "Students' conception on sizes and distances of the earth-moon-sun models." *European Journal of Social Sciences* 32, no. 4 (2012): 583-597.

[3] Danaia, Lena, and David H. McKINNON. "Common alternative astronomical conceptions encountered in junior secondary science classes: Why is this so?." *Astronomy Education Review* 6, no. 2 (2007).

[4] Ercan, Orhan, Kadir Bilen, and Evrim Ural. "'Earth, Sun and Moon': Computer assisted instruction in secondary school science-achievement and attitudes." *Issues in Educational Research* 26, no. 2 (2016): 206.

[5] Kapp, Karl M. *The gamification of learning and instruction fieldbook: Ideas into practice*. John Wiley & Sons, 2013.

[6] Karttunen, Hannu, Pekka Kröger, Heikki Oja, Markku Poutanen, and Karl Johan Donner, eds. *Fundamental astronomy*. Springer, 2016.

[7] Kiili, Kristian. "Digital game-based learning: Towards an experiential gaming model." *The Internet and higher education* 8, no. 1 (2005): 13-24.

[8] Kıroğlu, Kasım. "Students Are Not Highly Familiar with Astronomy Concepts–But What about the Teachers?." *Journal of Education and Training Studies* 3, no. 4 (2015): 31-41.

[9] Küçüközer, Hüseyin, M. Emin Korkusuz, H. Asuman Küçüközer, and Kemal Yürümezoğlu. "The effect of 3D computer modeling and observation-based instruction on the conceptual change regarding basic concepts of astronomy in elementary school students." *Astronomy Education Review* 8, no. 1 (2009): 010104.

[10] McClarty, Katie Larsen, Aline Orr, Peter M. Frey, Robert P. Dolan, Victoria Vassileva, and Aaron McVay. "A literature review of gaming in education." *Gaming in education* (2012): 1-35.

[11] Miranda, Rommel J. "Urban middle-school teachers' beliefs about astronomy learner characteristics: Implications for curriculum." *Astronomy education review* 9, no. 1 (2010): 1-9.

[12] Percy, J. R. (2006). Teaching Astronomy? Why and How? Journal of the American Association of Variable Star Observers (JAAVSO), 35(248-254).

[13] Perrotta, Carlo, Gill Featherstone, Helen Aston, and Emily Houghton. "Game-based learning: Latest evidence and future directions." *Slough: NFER* (2013).

[14] Ramadan, Rido, and Yani Widyani. "Game development life cycle guidelines." In *2013 International Conference on Advanced Computer Science and Information Systems (ICACSIS)*, pp. 95-100. IEEE, 2013.

[15] Subodh, M. (2013). Founder of modern astronomy : from hipparchus to hawking. [Place of publication not identified]: Vigyan Prasar.

[16] Trumper, Ricardo. "Teaching future teachers basic astronomy concepts—seasonal changes—at a time of reform in science education." *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching* 43, no. 9 (2006): 879-906.

[17] Turkmen, Hakan. "After almost half-century landing on the moon and still countering basic astronomy conceptions." *European Journal of Physics Education* 6, no. 2 (2017): 1-17.

[18] Van Eck, Richard. "Digital game-based learning: It's not just the digital natives who are restless." *EDUCAUSE review* 41, no. 2 (2006): 16.

[19] Perrotta, Carlo, Gill Featherstone, Helen Aston, and Emily Houghton. "Game-based learning: Latest evidence and

future directions." *Slough: NFER* (2013).

24