

Gamification Design Framework to Support Interaction Skills in Mathematics Learning: A Systematic Review

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Abstract

This systematic review article focuses on the gamification design framework in supporting interaction skills in Mathematics learning. The fact that gamification is not a new phenomenon has attracted researchers to conduct several relevant studies. Unfortunately, previous studies were not targeting the interaction skills for Mathematics learning especially in the Malaysian environment. Thus, the present study reviewed a considerable amount of past literature on the mentioned viewpoints. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was adopted for the review of the current research, which utilized the IEEE database. Significantly, the review managed to formulate themes and present several recommendations at the end of this research for future scholars' reference.

Keywords: *Mathematics learning, Design, Framework, Gamification, Interaction.*

1. Introduction

Learning is primarily a social activity (Dewey, 1963). The basic idea behind learning is that the person who is doing the work is the person doing the learning (Hurst, 1998). Mathematics learning achievement is influenced by the internal and external factor of the students. One of the influencing external factors is social interaction with friends and teachers in learning activities. Social interaction is the key of all social life because without social interaction, it is impossible for having life together because social interaction with individuals or other groups contribute to our well-being (Sandstrom & Dunn, 2014).

In modern learning, the learning is student-centered, so the student interaction is needed to learn about certain basic competence. Potential and motivation of students in learning are expected to develop with good social interaction in order to get maximum results. Social interaction is an important aspect of learning Mathematics because students get the opportunity to express their own thoughts in order to encourage a reflection on the knowledge they have.

Collaboration and competition in gamification are the interventions that encourage social interaction among students (Rigby and Ryan 2011). These findings have led to a widespread digital games production for learning as well as gamification application in Mathematics learning. However, the effectiveness for the intervention treatment in Malaysian learning environment especially for Mathematics learning is still unclear.

2. The Need for A Systematics Review

According to Sofaer & Strech (2012), the primary purpose of the systematic review is to improve decisions. As such the use of systematic literature review enables decisions that are maximally informed and minimally biased. Systematic reviews search, evaluate and arrange all relevant empirical evidence in order to provide a complete interpretation of research results.

The current paper attempts to systematically review all the appropriate literature to fulfil the gap by examining a growing body of evidence on the gamification in Mathematics learning in Malaysia with regards to their interaction skills. Also, the present study is important because it provides information on the extent of the focus of peer review literature, which can assist scholars in delivering the prospect to understand future attention related to gamification concerns.

The current systematic review development and writing are based on the main research question: How can gamification be incorporated for Mathematics learning in Malaysia specifically about their interaction skills? The principal focus of the investigation was on the design frameworks.

This section discusses the need to conduct a systematic review of Mathematics learning while the following section presents the approach that was employed to obtain the answer to the research question formulated by the current research. Then, the third section conducts a systematic review and synthesizes the scientific literature to distinguish, select and evaluate the significant research on the gamification framework towards interaction skills of Mathematics learning. Finally, the last section examines the measure that needs to be taken when focusing on future researchers concerning the concerns being raised.

3. Material and Methods

This section is divided into four main sub-sections; PRISMA, resources, the systematic review process, and data abstraction and analysis, which are employed in the current research.

PRISMA

Publication standards are required to guide authors with the related and necessary material that will enable them to evaluate and examine the quality of a review. One of the published standards in conducting systematic literature reviews is called PRISMA or Preferred Reporting Items for Systematic Reviews and Meta-Analyses. PRISMA is an evidence-based minimum set of items for reporting in systematic reviews and meta-analyses (PRISMA, 2021). PRISMA was originally published in 2009 to help systematic reviewers transparently report why the review was done, what the authors did, and what they found. Currently, the updated PRISMA 2020 statement replaces the 2009 statement and includes new reporting guidance that reflects advances in methods to identify, select, appraise, and synthesize studies (Page, McKenzie, Bossuyt, *et al*, 2021).

Resources

Methods of the review for this conference paper were conducted using one database which is the IEEE. The IEEE database was included as it indexes computing and information system related studies related studies including gamification. However, it should be noted that no database is perfect or comprehensive. Furthermore, suggestion on which search engines and bibliographic databases to choose for systematic searches is limited and lacking systematic, empirical performance assessments (Gusenbauer & R. Haddaway, 2019). Therefore, scholars should conduct their searching process using numerous databases to increase the possibility of obtaining significant and related articles. However, the present paper only presented the outcome from one database related to gamification.

Systematic Review Process for Articles Selection

The systematic review process for articles selection consists three sub-sections; identification, screening and eligibility, which are the main and fundamental process for systematic review articles selection.

Identification

The first step in the systematic review process for articles selection is the keywords identification, followed by the process of searching for related and similar terms based on the dictionaries, thesaurus and past researches. Thus, the search strings database were developed in October 2021 (Refer to Table 1) after all relevant keywords were determined. Most importantly, the current research work successfully retrieved a total of 5 articles from the IEEE database. As formerly stated, manual searching was conducted and additional numbers of twenty articles were found based on similar keywords. Altogether, 25 articles were retrieved in the first step of the systematic review process

Table 1: The Search String

Database Search String	
IEEE	TITLE-ABS-KEY(("Gamification* design*" OR "Gamification* framework*" OR "Gamification* model*") AND ("Mathematics") AND ("Interaction*" OR "Interaction* skill*" OR "Interaction* support*"))

Screening

The purpose of the first step of screening was to remove duplicate articles. In this case, two articles were excluded during the first step, while a total of 23 articles were screened based on inclusion and exclusion criteria determined by the researchers in the second step. The first criterion is the literature type where the researchers decided to focus only on the journal research article and conference proceeding due to its primary sources that offer empirical data. Thus, this further signifies that publication in the form of the systematic review, book chapter, and journals review were excluded in the current research. Furthermore, the review only focused on English articles. Additionally, it should be noted that 9 years (2011- 2020) was selected for the timeline. On top of that, to increase the possibility of retrieving related articles, articles published in psychology and medical health, as well as articles associated with serious games, were selected. Overall, a total of 12 articles were excluded based on these criteria (Refer to Table 2)

Table 2: The Inclusion and Exclusion Criteria

Criterion	Eligibility	Exclusion
Literature Type	Journal (research articles), Conference proceeding (research articles)	Journals (review), chapter in the book and editorial.
Language	English	Non- English
Timeline	Between 2011 and 2020	< 2011
Subject area	Computer Science, Information Systems, Serious Games, Medical Health and Psychology	Other than Computer Science, Information Systems, Serious Games, Medical Health and Psychology

Eligibility

A total of 11 articles were prepared for the third step known as the eligibility. In this significant step, the titles, abstracts and the main content of all the articles were assessed thoroughly to ensure that they fulfilled the inclusion criteria and suitable to be used in the present study to achieve the objectives of the current research. Therefore, a total of 6 articles were excluded due to non-focusing on gamification and serious games issues related to mathematics. Conclusively, only 5 remaining articles are ready to be analyzed.

Data Abstraction and Analysis

The integrated review is one of the review techniques that analyzes and synthesizes diverse research designs together (qualitative, quantitative and mixed methods). This study chooses to quality all selected data. Thematic analysis is carried out to develop the appropriate themes in this study. Data compilation is done where the authors thoroughly analyzed a group of 5 selected articles to extract statements or data that answers the research question. Hence, the process has resulted in two main themes namely immersive and personalization.

4. Results

The analysis produced a total of two themes related to gamification application and mathematics. The two themes are immersive and personalization. More specifically, it should be noted that five previous studies (Feng, Liu, Qian, Guo & Chen, 2019; Jagušt, Boticki, Mornar & So, 2017; Lubis, Rosmansyah, & Supangkat, 2014; Kekuluthotuwage & Fernando, 2017; Toda, do Carmo, Campos, da Silva, & Brancher, 2015) focused on social, communications, and emotions where those aspects are measured to be important in the development of interaction skills.

Immersive

Gamification design towards interactions skills for mathematics subject seems to be related to immersive experience (Feng, Liu, Qian, Guo & Chen, 2019). The study have shown that two gamification elements (social and immersive elements) positively influence expectation confirmation and perceived usefulness, which in turn, positively affect user's satisfaction and continuance intention. However, gamification elements should be approach with caution as the employed gamification mechanisms occasionally, in case of particular students, led to non-favorable results (Jagušt, Boticki, Mornar & So, 2017).

Personalization

Gamification framework requires personalization of user to be adopted in the development process. (Lubis, Rosmansyah, & Supangkat, 2014; Kekuluthotuwage & Fernando, 2017; Jagušt, Boticki, Mornar & So, 2017). The range of user is highly dependent on the behaviors targeted in its design. Therefore, the gamification needs to be able to correspond to a broad range of users characteristics and context (Toda, do Carmo, Campos, da Silva, & Brancher, 2015). Providing a real-world experience that users can relate to would enable them to be more aware of the potential benefits of experience and helping to better manage user expectations (Toda, do Carmo, Campos, da Silva, & Brancher, 2015).

5. Discussions

In this study, two themes were formulated from the systematic literature review process namely immersive and personalization. All these elements reflected as significant aspects or elements that should be incorporated and adopted in gamification design framework to ensure the effectiveness of the application. Also, to have meaningful gamification, the application should be able to improve user experience and user engagement (Sanmugam, Abdullah & Zaid, 2014). In addition, this study is referring to interaction skills in terms of how the gamification can assist mathematics students to improve their interaction skills as a support and an intervention approach from the conventional tutorial and lecture handled by the lecturer.

Furthermore, targeting multiple behaviours in the gamification design would allow an individual mathematics student to learn, practice and improve their difficulties in one or more behaviours targeted in the gamification application. Personalization is better to be integrated into gamification to correspond to a broad range of student characteristics and context. In designing the gamification, there has to be a room for personalization of therapy goals. Providing a real-world experience that users can relate to would make them more aware of the gamification potential, and thus help to

better manage user expectations (Toda, do Carmo, Campos, da Silva, & Brancher, 2015). This could be done either explicitly by manually personalizing the game content or more implicitly, through automatic adaptation based on player preferences or modelling technique.

6. Recommendations

The findings and systematic review process of the present study have led to several recommendations that may be helpful for future scholars. First, future studies should be conducted using other available database such as Google Scholar, Scopus and Web of Science database to obtain more relevant articles. In this study, due to limitation of time and database access, articles were obtained from only one database. Meanwhile, it should be noted that various keywords could be added to increase the relevant articles to be analyzed. For example, the “interaction” keyword for the search strings could be further improved by adding keywords such as “social”, and “communication”. Other than “interaction” keyword, the “gamification” keyword can also be added as “serious games” as both terms share a common goal. Regardless, both gamification and serious games capitalize on the popularity nature of recreational digital games. On another note, it should be realized that all of the articles analyzed in this study are only conference proceeding articles. Thus, results analysis could be improved if journal articles were also included for review.

8. Conclusions

In this paper, a systematic literature review process has been discussed and associated with gamification design framework for mathematics students aimed at supporting the students social and interaction skills. Furthermore, two main themes that represent the gamification design framework were identified based on the systematic review performed through the current research. The first theme refers to an immersive experience, which could be incorporated into the design framework to improve the user’s engagement as well as user experiences. Next, the second theme is known as personalization, which allows mathematics students to learn, practice and improve their difficulties in one or more topics.

The key contribution in this paper is to provide more knowledge about designing gamification to be used by mathematics students and to support their interaction skills. Detailed descriptions of the systematic review process as well as the recommendations of gamification design framework in this context are provided. In the future, the structural design framework recommended in this study can be used as the basis for the development of a gamification framework for mathematics students specifically related to their interaction skill.

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