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# GAMIFICATION DESIGN FOR ONLINE LEARNING OF INTRODUCTORY PROGRAMMING: A COMPARATIVE ANALYSIS

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**ABSTRACT**

*This paper discusses the gamification design recommended for an online learning platform specifically for the introductory programming course. Initially, during literature search, more than 50 existing studies were manually selected through various literature databases. It then led to the selection of ten studies that utilised gamification design principles in online learning platforms to learn introductory programming in higher learning institutions based on the pre-determined themes during the extraction and filtration phase. A further detailed criteria of the comparative analysis during the review and analysis phase were then applied which resulted in the findings of the gamification framework, gamification principles, and gamification elements suitable for the gamified online learning environment of the introductory programming course.*

***Keywords: gamification, design principles, introductory programming, online learning***

## Introduction

In facilitating the teaching and learning of introductory programming, over these years, many studies have utilised online learning platforms. For example, a study done by Karnalim and Ayub (2017) have resulted in a development of an online learning system named PythonTutor to support the teaching and learning of an introductory programming course. The system was embedded with the visualisation technique claimed to have positive impacts towards students' understanding in programming, especially at their early stages. Moreover, Carbonaro (2018) has utilised a web-based peer code review and assessment to promote students' engagement and participation in the coding experience, while also providing feedback to their peers. The web-based programming assistance system enhances students' programming skills, engagement, and time management abilities. Through this approach, students are involved not only as learners but also as reviewers.

Additionally, gamification in online learning environments to learn introductory programming has also gained interest among researchers and academicians. For instance, a study done by Khaleel et al. (2019) has used the Mechanics-Dynamics-Aesthetics (MDA) Framework as the design guidelines in the development of the gamification-based learning website to learn Java programming. According

to the study, the structure of the gamification application encompasses several key components: mechanics, which are the tools of gamification integrated with programming content to enhance student effectiveness and make the programming course more engaging; dynamics, which involve how users interact with these mechanics; and aesthetics, which pertain to the emotional responses elicited by the application's design. The use of the MDA Framework facilitated the inclusion of various gamification elements in the online learning system, including levels, a scoring system, badges, and a leaderboard, all aimed at creating a compelling user interface.

Nevertheless, designing a gamified online learning posed challenges for many instructional designers (Hunicke et al., 2004; Deterding et al., 2011). One needs to consider the game mechanics and how to dynamically instruct them to successfully deliver a gameful experience and invoking aesthetics emotions (Hunicke et al., 2004; Khaleel et al., 2019). Hence, understanding the framework, principles and elements of gamification can help to design gamified online learning that are more interactive, engaging and motivating for the introductory programming course. Therefore, this paper seeks to identify and extract the suitable gamification framework, principles and elements to be employed in a gamified online learning environment for an introductory programming course through a comparative analysis. The structure of this paper starts with the explanation of the methodology for the comparative analysis, followed by the findings and conclusions.

**Methodology**

This study employed the qualitative approach using the comparative analysis technique adopted from Ahmad and Abdul Mutalib (2015) which involves three main phases, i) literature search, ii) elicitation and filtration, and iii) review and analysis.

The following is the description of each of the phases involved in conducting the comparative analysis:

a) Literature search

In the first phase, an extensive literature search was conducted through various literature databases such as Scopus, Web of Science (WoS), IEEE and Google Scholar. This was to search for articles that are related to the implementation of gamification in online learning platforms, specifically in learning introductory programming. The search for the articles is being done throughout the year 2018 until 2023. Several keywords have been used, such as “introductory programming”, “online learning”, “gamification for education”, “gamification principles”, and “gamification elements”.

b) Elicitation and filtration

Through manual selection, initially, more than 50 articles were selected. To further select the most suitable articles for this study, certain themes have been pre-determined where all selected studies must i) be related to the online learning for introductory programming courses in higher learning institutions, ii) discussed the gamification framework they have referred to, iii) discussed the gamification principles that they have employed in the online learning platform, and iv) discussed the gamification elements used in the study.

Therefore, based on the pre-determined themes, only ten articles have been deemed suitable for further review and analysis. All ten selected articles have extensively discussed the implementation of gamification in online learning platforms to support the teaching and learning of introductory programming in higher learning institutions, which eventually helped to establish the direction of this study.

c) Review and analysis

All ten articles were further reviewed and analysed in terms of these criteria, i) gamification framework, ii) gamification principles, and iii) gamification elements. The following section will discuss in detail the review and analysis results.

**Findings**

As mentioned previously, all ten existing studies were selected based on the pre-determined themes. Table 1 shows the studies selected for the review and analysis process.

Table 1: The selected existing studies

| Author | Studies |
|---|---|
| Imran (2023) | A Gamified Learning Environment Model |
| Nadja (2022) | A Personalized Gamification Design Model (PeGAM) |
| Poonsawad et al. (2022) | Problem-based Interactive Digital Story Learning Model |
| Alsubhi et al. (2021) | Engagement Framework for E-learning Gamification |
| Kamunya et al. (2020) | An Adaptive Gamification Model of E-learning |
| Winanti et al. (2020) | Gamification Framework for Programming Course in Higher Education |
| Alshammari (2019) | Gamification Design Model for E-learning |
| Khaleel et al. (2019) | Gamification-based Learning Framework for a Programming Course |
| Padirayon (2019) | Gamification Application Architecture and Elements |
| Piteira et al. (2018) | Conceptual Framework of Gamification on Online Courses |

Through the review and analysis process, detailed criteria were extracted to determine the gamification design principles that are suitable for the online learning of introductory programming. As a result, Table 2 shows the findings of the comparative analysis conducted. As mentioned previously, the criteria extracted from the existing studies are the gamification framework, gamification principles and gamification elements.

Table 2: Comparative analysis of gamification implementation in online learning for introductory programming

| Author | Gamification Framework | Gamification Principles | Gamification Elements |
|---|---|---|---|
| Imran (2023) | MDA Framework | Progression, achievement, rules and challenges, storyline/narrative | Points, badges, levels, leaderboard, progress bar |
| Nadja (2022) | Adaptive user centred gamification framework | Progression, rules and challenges, feedback/achievement, sensation | Badges, leaderboard, progress bar, virtual goods |
| Poonsawad et al. (2022) | MDA Framework | Progression, rules and challenges, feedback/achievement storyline/narrative, sensation | Points, badges, levels, leaderboard, progress bar |
| Alsubhi et al. (2021) | MDA Framework | Progression, achievement, rules and challenges, sensation | Points, badges, levels, leaderboard, progress bar, timer |
| Kamunya et al. (2020) | MDA Framework | Rules and challenges, rewards/status, achievement, competition, altruism | Badges, leaderboard, progress bar, virtual goods |
| Winanti et al. (2020) | Gamification framework for K-6 education | Progression, achievement, rules and challenges, sensation | Points, badges, levels, leaderboard |
| Alshammari (2019) | MDA Framework | Rules and challenges, rewards/status, achievement, progression | Points, badges, levels, leaderboard, timer |
| Khaleel et al. (2019) | MDA Framework | Progression, achievement, rules and challenges, competition, altruism, sensation | Points, badges, levels, leaderboard, progress bar |
| Padirayon (2019) | MDA Framework | Progression, achievement, rules and challenges, sensation | Points, badges, levels, leaderboard, progress bar |
| Piteira et al. (2018) | Principles of Gamified Educational Design | Progression, achievement, rules and challenges, narrative, sensation | Points, badges, levels, leaderboard, progress bar |

Based on the findings depicted in Table 2, it has been found that the MDA Framework has been the most selected gamification framework among the existing studies, where seven out of ten studies have been referring to the MDA Framework. The MDA Framework, which stands for game Mechanics, Dynamics and Aesthetics was first introduced by Hunicke et al. (2004) to be used in the educational technology environment. The flexibility and adaptability of the three distinct layers of the MDA Framework have contributed to the widely applied gamification framework in the online learning environment for the introductory programming course as mentioned by Khaleel et al. (2019), Alsubhi et al. (2021) and Imran (2023). Additionally, the MDA Framework also focuses on the student's experiences and emotions which influences enjoyment, engagement and motivation (Alshammari, 2019; Poonsawad et al., 2022).

Meanwhile, Table 2 has also revealed that the most applied gamification principles for the online learning environment of learning introductory programming are achievement, rules and challenges, and progression. In most of the existing studies, the achievement principle represents the successful completion of a course, a lesson, or a challenge in a gamified online learning system (Padirayon, 2019; Alshammari, 2019; Nadja, 2022). In addition, the rules and challenges principles required a defined goal setting, telling learners what and how to achieve in a narrative or storyline. Other than that, challenges also serve as elements that instruct learners on the system's required actions, such as course obstacles that must be unlocked before progressing to the next level (Khaleel et al., 2019; Kamunya et al., 2020; Alsubhi et al., 2021; Imran, 2023). Moreover, the progression principle represented as ropes of engagement to keep users motivated and interested. Unlocking levels and interactive progress bars are typically used to represent a learner's progress (Piteira et al., 2018; Khaleel et al., 2019; Winanti et al., 2020; Poonsawad et al., 2022).

Furthermore, the gamification principles identified previously have also influenced the selection of the gamification elements among the existing studies. In most cases, as shown in Table 2, the gamification principles selected for the online learning of introductory programming often required the utilisation of gamification elements such as accumulating points, badges and acquiring ranks in the leaderboards that represent the achievement principle. Additionally, unlocking levels and progress bars also represent progression of accomplishing rules and challenges, which then led to invoking learners' sensation and motivation to stay engage with the online learning (Piteira et al., 2018; Khaleel et al., 2019; Winanti et al., 2020; Poonsawad et al., 2022. Nadja, 2022; Imran, 2023).

Therefore, based on the findings of the comparative analysis, a comprehensive gamification design can be conceptualised to provide guidance to the development of a gamified online learning

system for the introductory programming. Figure 1 shows the assimilation of the extracted gamification principles and elements and how it can be integrated within the three layers of the MDA Framework.

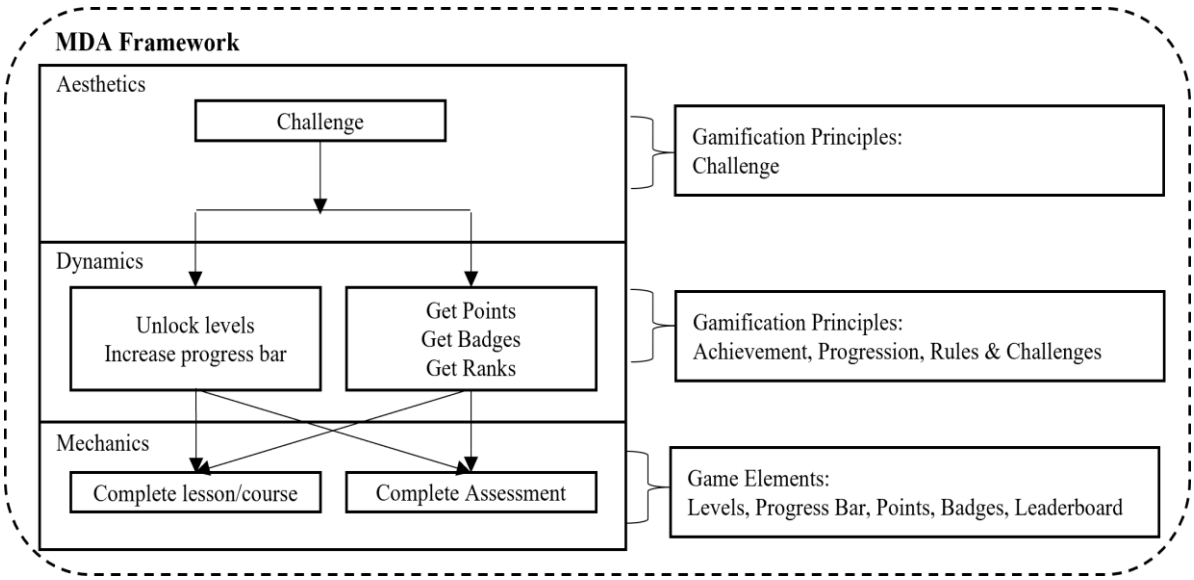


Figure 1: Integration of the recommended gamification design for a gamified online learning environment of introductory programming

**Conclusion**

Gamification design in online learning environments has been widely researched and implemented over the years. Nevertheless, in learning introductory programming via online platform, it is crucial to determine the suitable gamification design that would help learners to stay engaged with online learning, whilst improving their motivation. To achieve this, a comparative analysis among ten existing studies was conducted to identify and extract the suitable gamification framework, principles and elements for a gamified online learning environment of the introductory programming course. The findings have shown that the MDA Framework was most effective to be implemented in the online learning environment because of its flexibility and adaptability with its three distinct layers of gamification design; the game mechanics, dynamics and aesthetics. Meanwhile, the most suitable gamification principles identified are the achievement, rules and challenges, and progression, with gamification elements of points, badges, levels, leaderboards and progress bars. Each principle provides mechanisms to represent learners' accomplishments through narrative in challenges, and learners' progression in unlocking levels and proceeding in acquiring higher ranks. Additionally, the game elements represent the game mechanics that provide interactive elements for accumulating points and badges, virtual presentation of progress bars, unlocking levels and accomplishing ranks in the leaderboards. In conclusion, as a result of these findings, a conceptual gamification design has been developed, which

in hope to lead the development of a more effective gamified online learning system for introductory programming.

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