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Leveraging Gamification in Science Learning for Secondary Students

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ABSTRACT

This project aims to study the usefulness of incorporating gamification for science learning, for secondary school students. Ever since, the Science subject has been a hassle to the students, as well as the teachers. Therefore, a web-based system with gamification has been proposed. The waterfall model was chosen as the project's methodology, which consists of planning, analysis, design, implementation, testing, and documentation phases. Firebase was used as the cloud database to ease data storage and analysis. The selection was made to ensure the data from interactive activities such as watching films and doing exercises was securely gathered and used. Students earned points, badges, and were ranked as they performed assignments, adding a competitive element to the learning experience. A usability test was carried out to assess the success of the gamified learning platform using PSSUQ (Post-Study System Usability Questionnaire). The survey participants were chosen randomly from a group of high school students and teachers. After using the gamified website, they were asked to submit feedback by answering 16 constructed questions. Positive feedback was gathered from the survey, as most of the questions recorded mean values between 4.0 and 4.5. Hopefully, this study will provide further information regarding the effectiveness of gamification in learning, particularly in science learning for secondary students.

Keywords: gamification, Science, learning, secondary students

1 INTRODUCTION

The World Health Organization (WHO) proclaimed a pandemic scenario in January 2020 because of the Covid-19 outbreak triggered by the transmission of a novel kind of coronavirus. All nations have closed all sectors, including the education sector, in accordance with the announcement of this epidemic. As a result, during the period of the Movement Control Order (PKP), the traditional face-to-face teaching and learning method had to be discontinued. According to Mukhtar et al. [1], many institutions are now interested in finding the most effective ways to distribute course material online, engage students, and administer exams. Despite being a risk to humanity, Covid-19 has caused institutions to invest in online learning. One of the most affected and crucial subjects is Science, which totally needs consideration for the teaching and learning process. The requirement of conducting the science learning process is very challenging. Students' lack of interest in science courses in primary school is primarily due to issues with science education at schools. Students frequently complain that

studying math and science is uninteresting. Data has shown that there is a drop in science subject for passed students in 2019, compared to 2018 in Malaysian Certificate of Education (SPM) which is a few months before the Covid-19 outbreak [2]. Nevertheless, the urge to increase exposure to science is high, as stated in the National Education Blueprint 2013-2025 [3]. In consequence, there are myriad approaches, and new opportunities of teaching and learning, such as in the technological approach, have emerged to attract students at each level to venture into the science field and then become experts in the country.

2 LITERATURE

In the last 10 years, gamification has become a popular strategy in higher education. Gamification is generally understood to refer to the use of game features in non-game contexts to draw attention and influence behaviour. Gamification is used in higher education to engage and encourage students [4],[5] with the end objective of raising final grades and academic performance. The same goes for gamified educational activities, which are typically computer-assisted and created in a digital setting.

2.1 Game Mechanics

The components utilized to gamify an eLearning course are termed gamification mechanics, game mechanics, or verbs of gamification. The student is placed in the centre of the activity while also being constrained in certain ways to make a challenge. These include activities, control mechanisms, and procedures that are typically seen in games. How anything (in this context, a game or gamified eLearning course) functions is referred to as its "mechanics." Numerous gamification mechanisms are listed in various sources, but only seven are universally acknowledged and often employed such as point, badge, level, progress bar, leaderboard, reward, and learner interaction [6].

Users are rewarded with points for their engagement, advancement, and accomplishments. Earning points gives students a sense of advancement and mastery [7]. When players perform activities or develop talents, they may be rewarded with points, which can also be used to maintain track and decide the winner state. The core of the reward system is the point system, which may be created as coins or virtual money. Points are one of the most often utilized components in gamification design and are frequently coupled with badges, levels, leaderboards, or status in the gamification of learning [8].

As a visible depiction of the player's accomplishment, badges are often shown as a shield or button and tied to the player's profile. Badges may be an effective tool for encouraging people to accomplish goals, pursue mastery, and participate in social competition [9]. The motivation for people to gather stuff is also connected to badges. Players are encouraged to gather badges when a list of them is made available to them.

Badges are frequently given out in the gamification of learning when a goal is met, an exceptional performance is noticed, or they can be utilized as a surprise present to keep people interested throughout the process [9]. They communicate to the pupils the desired behaviours and important course components. A list of participants with high scores in a game or activity that resembles a game is displayed on leaderboards [10]. They encourage rivalry among players and reward high scorers with bragging rights and social capital [11]. A leaderboard might be a strong incentive for both individual and team participants in the gamification of learning and can enhance course success. One

of the most popular but frequently criticized game components in the context of teaching is a leaderboard. According to some academics, the leaderboard's competition may demotivate learners who aren't as competitive or status conscious. There are numerous tactics that instructional designers and teachers might use to lessen the leaderboards' negative effects. By having players compete against their own personal bests and rewarding learners for their progress.

2.2 Science Education

National progress is greatly influenced by science. Malaysia's science curriculum was implemented in accordance with the National Education Philosophy, which advocates for a rule-unity between knowledge, attitude, and complete values [12]. Science is a core topic in the primary and secondary levels of education in Malaysia. Depending on the course chosen, upper secondary scientific courses are available in Core Science, Science Additional, and Elective Science, which include Biology, Chemistry, and Physics.

Due to traditional teaching methods, which exclude the use of teaching aids, most pupils can lose interest or concentration in science classes, particularly when Covid-19 started [13]. The use of electronic tools like playing videos in class is more appealing to today's youth. Students of today are different from those of the past. They require a method of thinking while solving problems as well as a grasp of things from numerous angles. A 21st century learning process is difficult for students in remote locations to obtain in most schools since they lack appropriate basic facilities and a conducive environment for learning, especially in rural or remote schools. These schools also lack ICT capabilities. Some urban schools continue to use the outdated "chalk and talk" method of instruction because their instructors lack the training necessary to make the most of the ICT resources available to them in every classroom. Due to this, ICT and STEM concepts are challenging to apply in teaching and learning, and a teacher's teaching options are constrained. Students have become disinterested in the subject due to boring instruction and improper learning techniques. As a result, students' enthusiasm in learning science and math has been impacted by the lack of infrastructure resources [14].

3 METHODOLOGY

The method chosen must be acceptable and appropriate for the project's design, as it will serve as a step-by-step guide that the developer must follow to efficiently provide the process [15]. The methodology used in this project research will be explained in detail in this chapter, along with each step taken to achieve the main goal of the study, to develop a gamification environment of science learning for secondary school students. Planning, analysis, design, implementation, testing, and documentation are the six steps of the waterfall process. Figure 1 depicts the overall process of this analysis procedure.

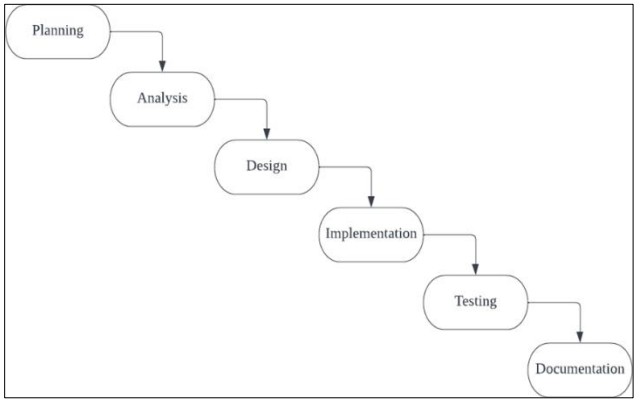

Figure 1: Waterfall Model

In Planning phase, the problem statement has been formulated after some investigation on the present educational website. In the Analysis phase, a survey of the literature on online education systems has been completed, which contains data on web-based application development, current website education systems, and websites that use gamification. The selected content for the prototype is the Force and Pressure topic as proposed by the teachers, which is one of the hardest topics in the syllabus. In the Design stage, which is where the project's development begins. User interfaces, databases, and many other related elements were designed in this phase. The process must be correctly planned, and the system's responsibilities must be clearly defined. Adobe XD was used to design the system's user interface. All system-related tables for databases were built to decide what information is stored in the database and what the user needs to see. In the Implementation phase, the source codes have been developed. The proposed system utilizes gamification elements such as point, badge, and leaderboard, whereby the web-based was built using WordPress. Firebase was used for the cloud database. The Testing phase started after the system was completed and free from errors. Twenty-three respondents were chosen from among high school students, and they answered the usability questions using Post-Study System Usability Questionnaire (PSSUQ) questionnaire through Google Form. Documentation is the study's last stage. Information that is either published or included in the product is considered documentation. It clarifies the role of the web-based system, its goal, and other critical details. It also entails gathering, distilling, and coding printed materials for later use. The development of the prototype will be documented and included in a thorough thesis throughout this phase. The deliverable outcome of the documentation phase is a complete report and documents generated throughout the project development.

3.1 The Developed Prototype

A prototype has been developed based on the information and designs completed in Phase 1 and Phase 2. As aforementioned, the prototype has been developed by using WordPress and Firebase. Figure 2 shows the interfaces of the prototype; (a) is the main page; (b) is the Register page; (c) the Login page for the existing user, and (d) is the Menu of the prototype. The users can go to learn videos in Video menu and then can select the Quiz to test their understanding on the topics.

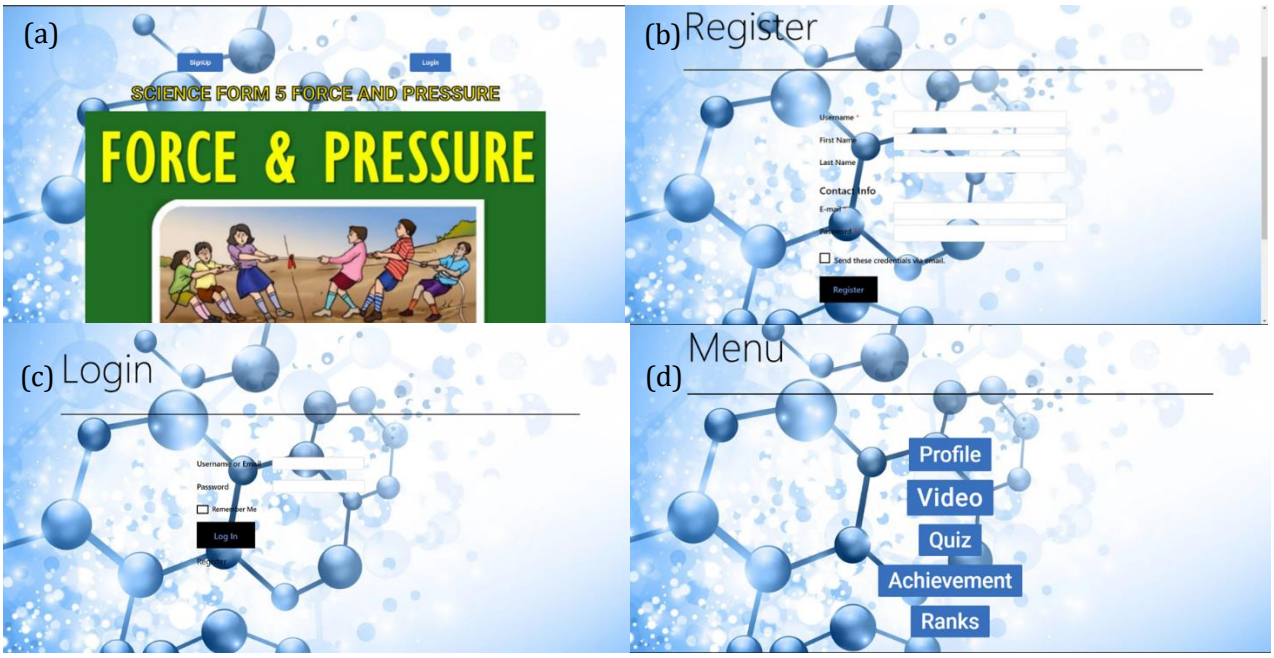

Figure 2: (a) Main Menu; (b) Register page; (c) Login page; (d) Menu page

Figure 3 the interface for, (a) videos collection for learning; (b) the quiz page, which the questions are based on the videos watched by the students; (c) the achievement page which contain Rising Star and MVPs achievement based on the points collected by the students; and lastly the rank or badge obtained by the students based on their achievement.

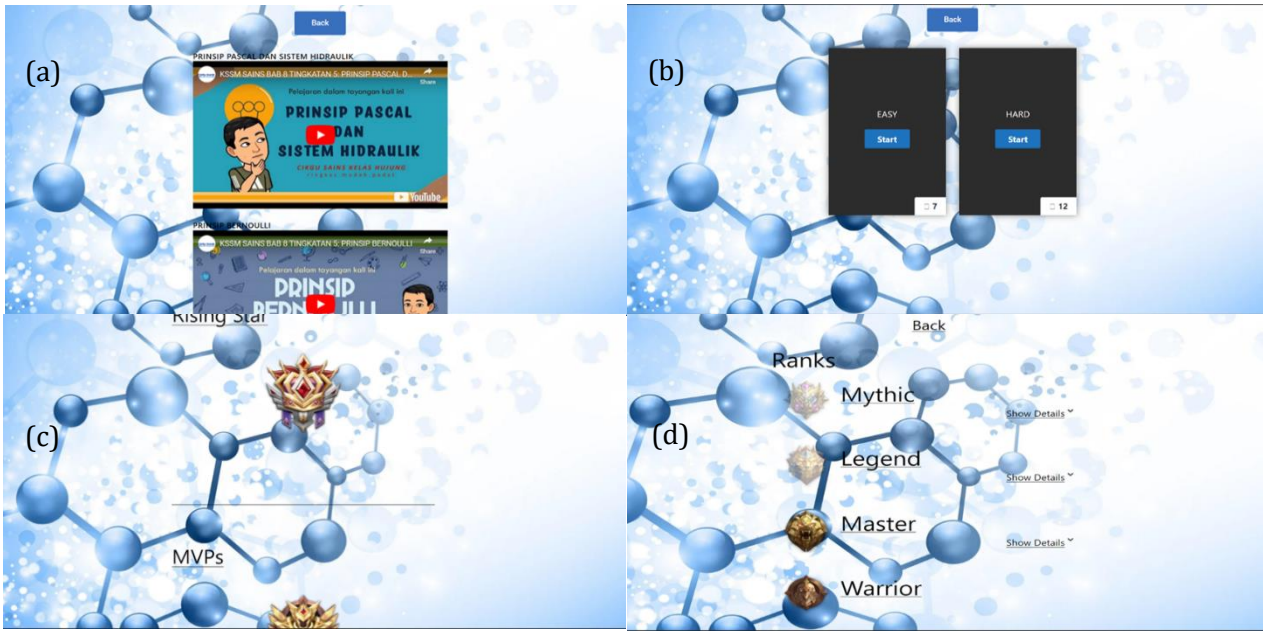

Figure 3: (a) Video page; (b) Quiz page; (c) Achievement page; (d) Rank page

4 RESULTS AND DISCUSSION

Usability testing is a research technique used to assess a product's or interface's usability and user experience. It entails watching people use the product to complete activities while gathering qualitative and quantitative information on their interactions, behaviour, and feedback. Finding usability problems, getting user feedback, and making wise design changes are the objectives. Participants in usability testing often execute realistic tasks while their actions, observations, and opinions are being recorded. To obtain information and develop a thorough picture of the user experience, researchers frequently utilise a range of techniques, including think-aloud procedures, screen recordings, surveys, and interviews. This study employed a survey which is the usability evaluation by using secondary school student as the respondents. 23 respondents involved in the testing as depicted in Figure 4. There were 60.9% female respondents and 39.1 % male respondents in this testing.

Table 1 shows the PSSUQ mean values for the 16 questions asked to the respondents. Overall, the results show that most respondents agreed with the asked items, in which all items have the mean values between 4.0 and 4.5, except for items 9 and 10. These two items were about the system interface, which is understandable since the interfaces still need improvements in the future. The simple interface was developed within the time constraint. However, the mean results show that the system is still acceptable to the students.

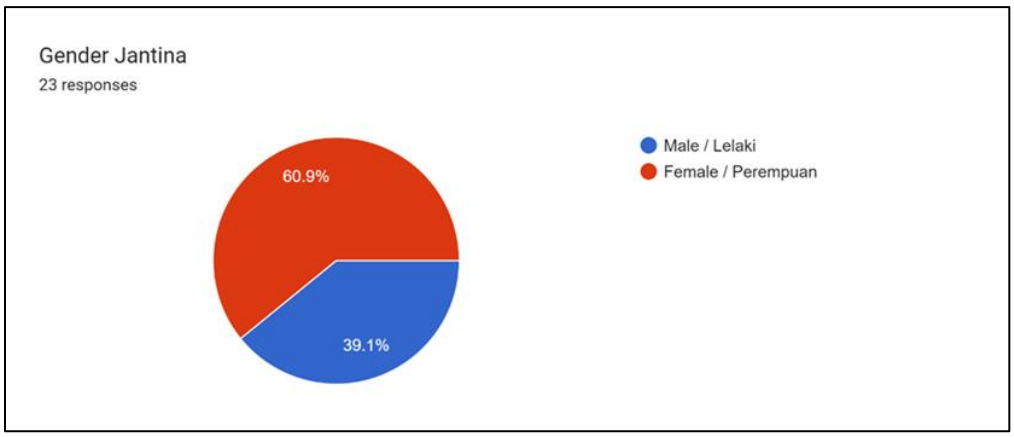

Figure 4: Percentage of Respondents

Table 1: PSSUQ Results

Questions	Mean
1) It was simple to use this system.	4.3
2) I could effectively complete the tasks and learning process using this system.	4.4
3) I was able to complete the tasks and learning process quickly using this system.	4.3
4) I felt comfortable using this system.	4.3
5) It was easy to learn to use this system.	4.4
6) It was easy to find the information I needed.	4.4
7) The information provided with this system was clear.	4.0
8) The information provided for the system was easy to understand.	4.4
9) The interface of this system was pleasant.	3.9
10) I liked using the interface of this system.	3.8
11) This system has all the functions and capabilities I expect it to have.	4.3
12) The organization of information on the system screens was clear.	4.2
13) Whenever I make a mistake using the system, it helps to understand the mistake.	4.3
14) Overall, I am satisfied with this system.	4.3
15) Overall, I am satisfied with how easy it is to use this system.	4.3
16) I believe I could become productive quickly using this system.	4.5

5 CONCLUSION AND RECOMMENDATIONS

This project's major goal is to use gamification techniques to assist high school students in learning science concepts related to force and pressure. Although gamification approaches might initially draw people and generate enthusiasm, it's crucial to make sure that the web-based system's core functionality or content is relevant and meaningful. In some instances, the gamification components may obscure the system's true goal or benefits. Users may be drawn in by the game-like aspects, but if the fundamental functionality or material is lacking in depth or does not adequately address their needs, engagement may only be fleeting. Users could rapidly lose interest if they realize that the gamified features are only a surface layer that don't offer any genuine benefits or worthwhile

experiences. Other than that, this project merely makes use of a small portion of the available gamification components. In this project, we solely use points, a ranking system, achievements, and badges. Finally, there is restricted long-term engagement. While maintaining long-term user interest with gamified web applications might be difficult, they can initially be engaging. Users can eventually lose interest if there aren't regular updates, new content, and growing challenges. Additionally, players may seek out other experiences or develop an immunity to the effects of the game mechanisms once the novelty of gamification wears off.

For recommendations, students need to be given extra gamification (game mechanics) options, so they won't get tired of the same function, instead of only point, badge, and leaderboard. The second suggestion is to add other science topics. Users with various interests and preferences can interact with the gamified system by adding new science topics. The new science topics that are relevant to their interests can captivate and inspire users who may not be as interested in the system's initial theme. Lastly, the last recommendation is to make regular updates and fresh content. To keep consumers interested and engaged, constantly add new tasks, levels, or information. To keep their interest and motivation, regularly add new features, rewards, or activities. The gamified website platform for science learning achieved its objective of offering a captivating and instructive experience. Utilising usability testing made it possible to gauge user pleasure and usability, yielding insightful results. Even though most users gave the platform positive reviews, it's critical to fix the problems that were found in subsequent initiatives. These flaws could relate to areas like user interface upgrades, content diversity, or additional customising options to accommodate varying learning preferences. By resolving these concerns, the platform can help secondary school students and the broader public learn about science even more effectively.

The gamified web platform has the potential to be an effective tool for science education, as seen by the participants' enthusiastic response. Because of its captivating character, it may hold students' interest and attention, making the process of learning science more pleasurable and efficient. Furthermore, the web-based platform's accessibility makes it generally accessible, allowing a wider audience to profit from the learning opportunities it offers. Using game mechanics like progress monitoring, prizes, and challenges, the gamified method also promotes a sense of motivation and accomplishment. This can improve learning by retaining knowledge, keeping students interested, and encouraging active engagement.

In the end, the findings of the study show that the gamified web platform for studying science has proven to be effective at retaining users and has gotten good reviews from users. It has a great deal of promise to help secondary school students and the public increase their grasp of science in a fun and approachable way by resolving the highlighted flaws and continuing enhancing the platform.

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