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Fisikawaii Adventure: An Effort to Increase Students' Learning Participation through Gamification and Virtual Reality

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Abstract

Student participation is critical in education. Technology integration, such as virtual reality, enhances the visualisation of physics concepts and participation. Combining virtual reality and gamification creates an immersive and interactive learning experience. This research aims to design and implement a learning management system (LMS) called Fisikawaii Adventure integrated with gamification and virtual reality. This study follows the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) development model. The motivational element of GAFCC (Goal, Access, Feedback, Challenge, and Collaboration) was employed in the design stage. The LMS was evaluated at SMAN 2 Bandar Lampung with ten eleventh-grade MIPA (Mathematics and Natural Science) students. The data collection technique employed was a non-test instrument. The data analysis technique was qualitative-quantitative using the Likert scale. Fisikawaii Adventure was valid with an average score of 85.5% from material experts, 87.25% from media experts, and 86.4% from student responses (very feasible category). The product was feasible to use in physics learning and increase students' participation. Although it requires further investigation, this research contributes significantly to integrating gamification and virtual reality into LMS and physics learning.

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INTRODUCTION

Students' participation and active involvement play a crucial part in increasing the effectiveness of learning (Chang et al., 2021); however, many students do not participate and are not motivated in the learning process (Sökmen, 2021) due to uninteresting learning methods (Hafizoglu & Yerdelen, 2019; Aydin et al., 2022), monotonous learning media (Puspitarini & Hanif, 2019), teacher-centered learning (Markina & Mollá, 2022), and passive learning (Kooloos et al., 2020). These issues lead to a drop in students' participation, which is currently a major issue in education (Cortes & Swanson, 2023; Schouten et al., 2022).

Efforts to promote student participation in learning can be made by incorporating technology into the learning process (Nurulsari et al., 2023; Ozcinar et al., 2021; Rohmah et al., 2023; Yuningsih et al., 2021; Zhang, 2022). incorporating cutting-edge technology into education can positively impact learning (Khaldi et al., 2023). Virtual reality technology can help us achieve successful

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learning reconstruction (Turan, 2021). This technology contributes to meeting contemporary educational demands and requirements (Bygstad et al., 2022), allowing students to study in a meaningful and participatory manner (Jääska et al., 2022) and redefining the roles of both teachers and students (Raja & Nagasubramani, 2018).

Virtual reality technology offers enormous potential to benefit a variety of fields of research, including physics (Iquira et al., 2019). Virtual reality technology can help students see and understand complex subjects while enhancing participation (Bully et al., 2020). This technology can also boost learning motivation and outcomes with a game-like approach (Jiang & Fryer, 2023). Therefore, adopting student-oriented and game-like virtual reality technology can improve physics teaching and learning (Olimovna, 2023). When implementing new technologies and methods in education, it is critical to address students' essential requirements, such as autonomy, competence, and relatedness (Huang & Hew, 2018). Consequently, the researchers investigated the GAFCC design and motivation theory (Goals, access, feedback, challenge, and collaboration) when integrating virtual reality technology and gamification.

Virtual reality is a technology that generates immersive simulations for students to engage in immersive and interactive experiences (Li et al, 2023; Fernández, 2021; Stylianou & Savva, 2022). It provides more realistic behavioural reactions (Girondini et al., 2023). It can also help students stay engaged and involved in simulated tasks that can be acquired and repeated (with or without failures) until they are flawlessly executed in a real-world setting (Bower et al., 2017). Virtual reality's adaptability allows integration with new ideas and technology (Martín-Gutiérrez et al., 2017). Gamification approaches can complement virtual reality (Roslan & Ayunb 2022). Gamification is a proactive approach that can boost student engagement and participation by incorporating game components into settings unrelated to the game (Tan & Cheah, 2021; Vieyra et al., 2020). Combining gamification with virtual reality provides benefits by creating an immersive and participatory learning environment where game components increase student motivation (Ahmed & Asiksoy, 2021). Virtual reality technology allows students to fully immerse themselves in a real and engaging learning experience (Makransky et al., 2019; Ulmer et al., 2022).

Research and development trends related to gamification and virtual reality have recently been widely studied (Bazargani et al., 2021; Camuñas-García et al., 2023; Chamorro-Atalaya et al., 2023; Hussain, 2023; Patsaki et al., 2022). The research spans multiple domains, including boosting rehabilitation programs (Kern et al., 2019) and lowering stress levels during gym training (Libriandy & Arlini, 2020). The maritime sector specifically raises knowledge of eco-efficiency during shipbuilding (Bully et al., 2020). In the industrial field, it strengthens navigation abilities (Mas et al., 2019) and digital learning architecture (Bucchiarone, 2022). Education can help students improve their spatial skills (Fernández, 2021; Wauck et al., 2019) and constructive and collaborative learning (Stylianou & Savva, 2022). In English learning, it boosts students' language skills (Pinto et al., 2021). It improves learning during physics practicum (Larsen et al., 2023). However, to our knowledge, no specialised research and development in physics learning incorporate gamification and virtual reality to promote student learning participation. This is consistent with the opinion (Ekici, 2021) that just a few studies address learning participation. A stronger emphasis on the impact of gamification on this variable could yield useful insights.

Therefore, this development research aimed to identify the steps involved in creating a Learning Management System (LMS) that incorporates gamification and virtual reality to improve students' participation and investigate how the students react to the designed LMS. The information transmission potential of further developing these technology-based learning platforms and tools is significant in today's educational context, which is progressively migrating online. Still, it can also aid in meeting the problems of sustainable future education.

METHOD

This research employed the R&D method and the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) (Branch, 2010). To ensure alignment with motivation theory during the design stage, the researchers used the GAFCC motivation theory model (Goal, Access, Feedback, Challenge, and Collaboration). This motivation theory suggests five key motivational elements for gamification design: aim, access, feedback, challenge, and collaboration.

Badges and leaderboards can be implemented as the five motivating elements (Huang & Hew, 2018). See Figure 1.

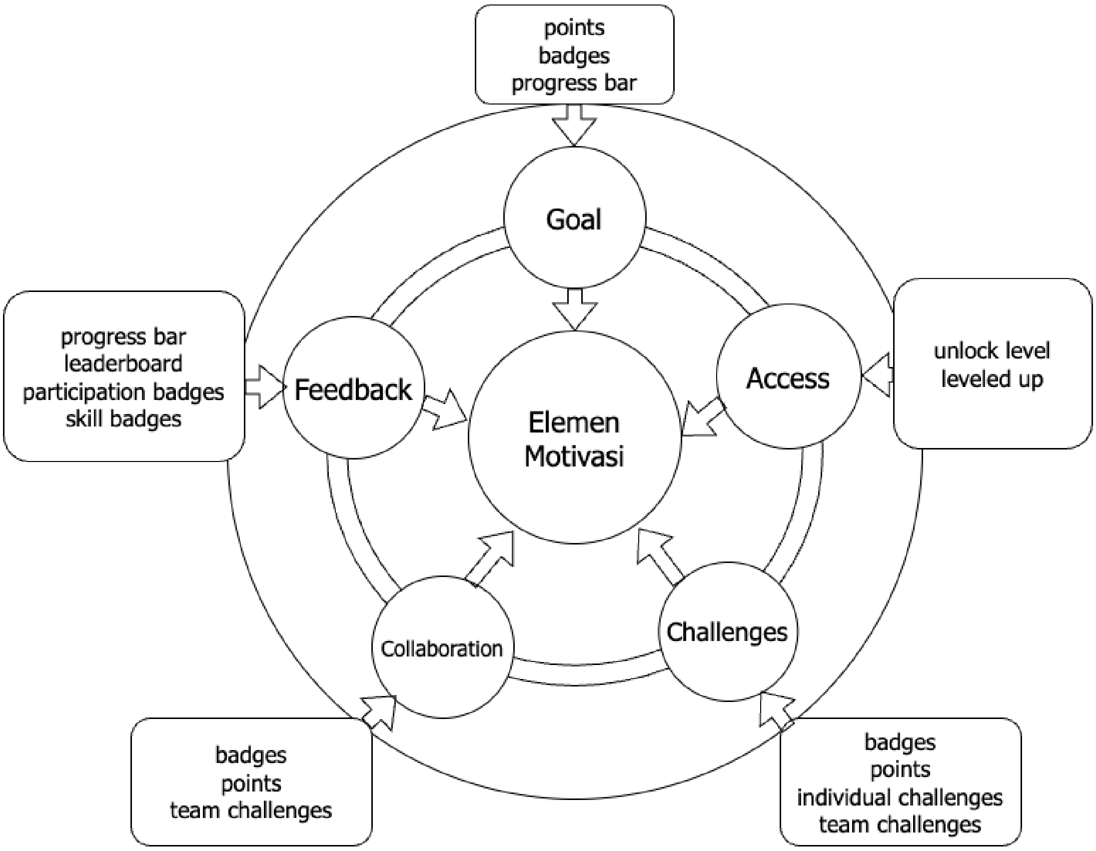


Figure 1. Motivational Needs, Motivational Elements, and Game Design Elements

In the previous section, the researchers discussed the theoretical components of the GAFCC model. The following section will review the practical methods for implementing this idea. To ensure compatibility between motivation theory, gamification approach, and instructional objectives, the researchers used the recommended five-stage design procedure from Huang and Hew(Huang & Hew, 2018). However, the researchers employed only four stages: examine, decide, match, and launch (Figure 2). One of the reasons for adopting only four of the five steps is to limit the scope of this study to determining student responses. Figure 2 depicts the steps in development research.

Analysis

This research consists of a needs analysis, a literature review, and field studies at the research site. Field studies assessed the potential and learning process of the eleventh-grade MIPA (Mathematics and Natural Science) of SMAN 2 Bandar Lampung. Based on observations and interviews, it was found that the 2013 curriculum was adopted. The students were passive participants in the learning process. They tended to be passive and struggled to understand physics lessons since they were only taught theory and not practice. Some students had little interest in physics, while others enjoyed it. Learning media was less varied, with just repetitive options available. In terms of school facilities, WiFi provides internet access. Students had cell phones, but they had not been used efficiently. Figure 2 contains a Flowchart of the ADDIE Development Model with Five-Stage Gamification Design.

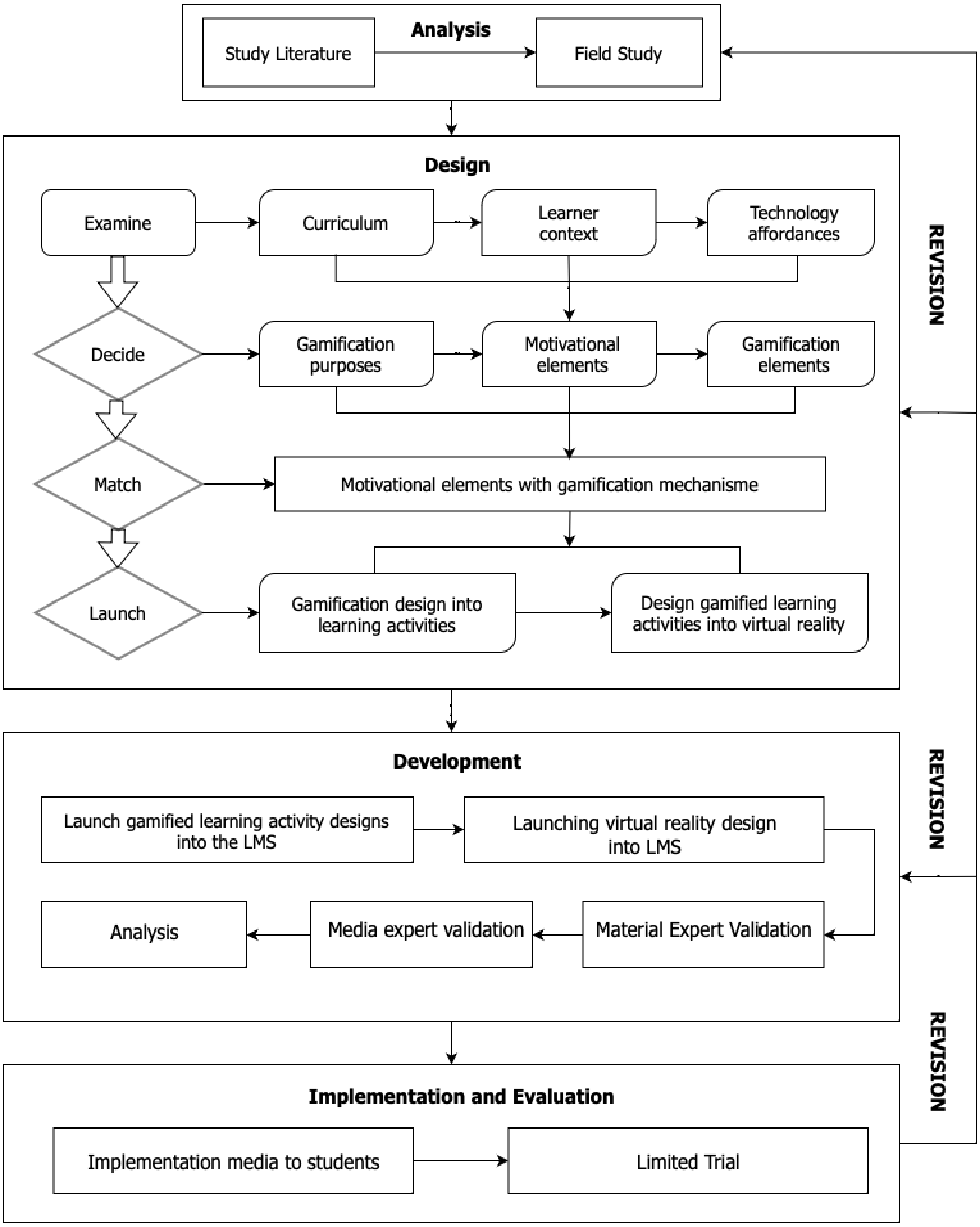


Figure 2. Flowchart of ADDIE Development Model with Five-Stage Gamification Design

Design

Several considerations should be explored in the design stage before embarking on designing and developing a gamified virtual reality educational application. One of these concerns is the alignment of motivational theories, gamification strategies, and instructional goals. As a result, the research design process was divided into four stages: checking, determining, matching, and launching (Huang & Hew, 2018).

The step began with the examination performed during the analytical stage, namely observation. In the determining section, it was decided that the goal of gamification was to apply game strategies to learning activities to improve students' "participation" in teaching and learning activities, allowing them to master and fulfil all learning objectives. Furthermore, the motivation element was based on a synthesis of five motivation theories summarised by Huang and Hew, suggesting that the available motivation aspects overlap, making it difficult to determine which is best. As a result, the researcher utilised the GAFCC motivation aspect (goal, access, feedback, challenge, and collaboration). These five motivational aspects were realised through gamification. In this research, the researchers used every available motivational aspect, including goal, access, feedback, challenge, and collaboration. This LMS contains the following elements: levels, missions, challenges, points, leaderboards, progress meters, narratives, points, and badges. Table 1 contains an explanation of each element.

Table 1. Gamification Elements

No	Gamification Elements	Description
1	Level and Mission	This web application design contains three levels corresponding to one chapter of topic matter. The inclusion of subject matter chapters to describe this level facilitates the development of game patterns. Completing subject matter sub-chapters describes the purpose of gamification. To complete a level, students must first complete a subject matter sub-chapter. Missions can be continued if students accomplish the previous mission by completing a quiz at the end of each level.
2	Challenges	The challenges in the web application explain the learning activities in each subject area sub-chapter. The challenges of each subject area sub-chapter may differ from one another. They are updated to reflect the design of the learning activities that have been prepared.
3	Point	Points stimulate participation, performance, competition, enjoyment, and effectiveness (Dermeval et al., 2019). In other words, the researchers want to encourage collaboration by introducing gamification features that improve student participation and help them maintain their efforts. Given that the app's intended audience consists of students who do not participate in physics, some extrinsic motivation, such as the desire to score higher, will assist them in exceeding their minimum expected requirements.
4	Progress Bars	A progress bar is also provided on the learning page and within the quiz to create a clear line to the quiz endpoint and to track their progress.
5	Leaderboard	The app has two leaderboards for individual quizzes and the overall score. The leaderboards serve to allow students to compare and compete. Separating the leaderboards gave students a good understanding of their progress on each item and overall performance relative to their peers. To further encourage participation and the achievement of learning objectives, achievements on the leaderboard can be applied to real-world rewards, such as bonus points to reward their efforts and quality time spent in the application.
6	Meaningful Stories	A meaningful story is an aspect of game design unrelated to player performance. Narrative context can be used in games to contextualise activities and characters, providing meaning beyond the quest for points and achievements (Kapp, 2012). The story in this article is set on the fictional planet Asgard, which is attacked by earth creatures due to its abundant natural resources. Then, Asgard loses in the middle of the battle and requests assistance from the universe's academics (students) in developing a rubber weapon based on solid elasticity material.
7	Badges	Badges are a more powerful version of points, a visual representation of some of the user's achievements in the system (Werbach & Hunter, 2012). They can be earned and collected in a gamified environment. Badges can be earned by accumulating certain points or engaging in specific in-game activities (Werbach & Hunter, 2012).

Matching motivational elements was done to determine the appropriateness of motivational elements and gamification mechanisms. This is consistent with Zainuddin et al.'s research, which found that many gamification studies fail to explain the theoretical relationship between gamification elements and their underlying mechanisms (Zainuddin et al., 2020). This design incorporates gamification elements, creating an engaging learning environment and encouraging active student participation. This step seeks to foster an interactive, dynamic, and enjoyable environment within the virtual learning space. Launching the virtual reality design in the LMS is a step toward providing an innovative and interactive learning experience. It can improve understanding of complex concepts by creating a more realistic and engaging learning environment. Thus, integrating VR into the LMS seeks to add a new dimension to education, increase students' participation, and create a more engaging and immersive learning environment.

Development

At this stage, the material and media validation of the developed media were completed. Material validation considered content feasibility, presentation feasibility, language assessment, and gamification assessment (Deterding et al., 2011). The media validation encompassed software, user interface, user experience (Smaldino et al., 2014), and gamification assessment (Deterding et al., 2011)

Implementation

The implementation stage began once the product had been validated by two validators, namely material validators and media validators. The product was then evaluated in a limited trial in which up to ten students from class XI MIPA participated to determine their responses. The stages of implementation are explained in the appendix.

Evaluation

The evaluation stage includes formative evaluation consistent with the study objectives, including determining the practicality of the developed media. The purposive sampling technique was utilised with ten students. The sampling criteria were high schools that applied the 2013 curriculum and eleventh-grade high school students that studied solid elasticity materials utilising an LMS. The research instruments included observation sheets, questionnaires, and graded scales. The researchers recruited ten students from class XI MIPA of SMAN 2 Bandar Lampung to participate in this research. These students were chosen because of their prior experience with LMS-based physics education. Although the gender distribution was not uniform, the participants were similar in that they attended the same department and school. First, the students were introduced to the concept of an interactive learning environment and the principles of learning participation. The pre-class stage took 20 minutes to complete. Following that, they were given a 15-minute quiz. The quiz consisted of multiple-choice questions and aimed to evaluate the pre-class activity so students had the same knowledge when learning activities. The data collection procedure was to select respondents, introduce the media to respondents, explain the purpose of developing learning media, conduct media trials, collect responses from respondents, and conduct data analysis. The data was analysed descriptively, using both qualitative and quantitative methods. The collected data was analysed using a Likert scale. The percentage of feasibility was calculated using the following equation (Sugiyono, 2014):

$$P = \frac{\sum x}{SMI} X\, 100\%$$

Description:

P = Percentage
$\sum$x = Total score
SM = Maximum score

The calculation of the overall percentage was performed with the following equation (Michael et al., 1991):

$$P = \frac{F}{N}$$

Description:
F = Overall percentage
N = The number of subjects
P = Percentage
After that, the results of the percentage score are categorised with the assessment criteria in Table 2 (Michael et al., 1991).

Table 2. Score Interpretation

Interval	Criteria
0 < x ≤ 20%	Highly not Feasible
20% < x ≤ 40%	Less feasible
40% < x ≤ 60%	Moderately Feasible
60% < x ≤ 80%	Feasible
80% < x ≤ 100%	Highly Feasible

RESULTS AND DISCUSSION

This section presents the research results to determine the development process of an LMS that incorporates gamification and virtual reality to support students' participation. The findings are divided into three subsections to address the research questions. First, the LMS development process is based on the design framework and motivation theory, as Figures 1 and 2 illustrate. The second is to conduct an LMS feasibility analysis. Third, consider how students respond to the LMS incorporating gamification and virtual reality.

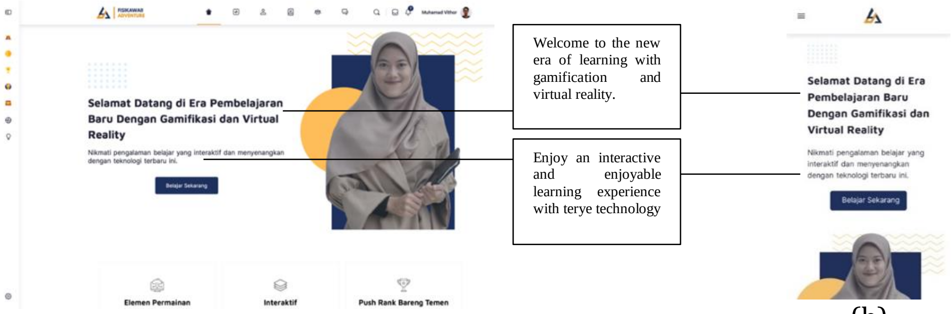
The Development Process of Fisikawaii Adventure LMS

This study reveals that the LMS development process consists of several structured steps. The first step was needs analysis, which involved a literature review to identify relevant concepts for developing the LMS. Field studies were also conducted to assess the potential and learning process at SMA Negeri 2 Bandar Lampung. Furthermore, the design stage combined the five-stage gamification design model with GAFCC motivational elements (goal, access, feedback, challenge, and collaboration). The learning foundation was based on solid elasticity learning material in the 2013 curriculum.

The LMS was built with WordPress (an open-source content management system). To create the LMS, the researchers used the LearnDashLMS plugin (an extension added to the WordPress website to modify and develop its main functions) in the following procedures:

1. Creating a site identity with domain: fisikawaii.my.id.
2. Purchasing hosting as a database at idCloudHosting.com.
3. Installing WordPress CMS on the fisikawaii.my.id site.
4. Installing BuddyBoss theme from Buddyboss.com.
5. Installing all the plugins listed in Appendix 1, especially the LearnDashLMS plugin.
6. Customising the site's interface by considering the user interface (UI).

The age of users, particularly teachers and students, must be considered when designing an LMS. To accommodate the age difference, the design employed Web 2.0 layout principles. The colours chosen were based on a flat palette, with navy as the primary colour, which was less likely to bore students and promote their participation in learning. The typography, such as "Inter" for the title and "Maven Pro" for the paragraphs, was chosen to improve readability. The design supported formal education's characteristics while remaining simple and appealing. The LMS Fisikawaii Adventure was designed with two navigation menus, one for smartphones and one for computer/laptop users (see Figure 3).



(a) (b)

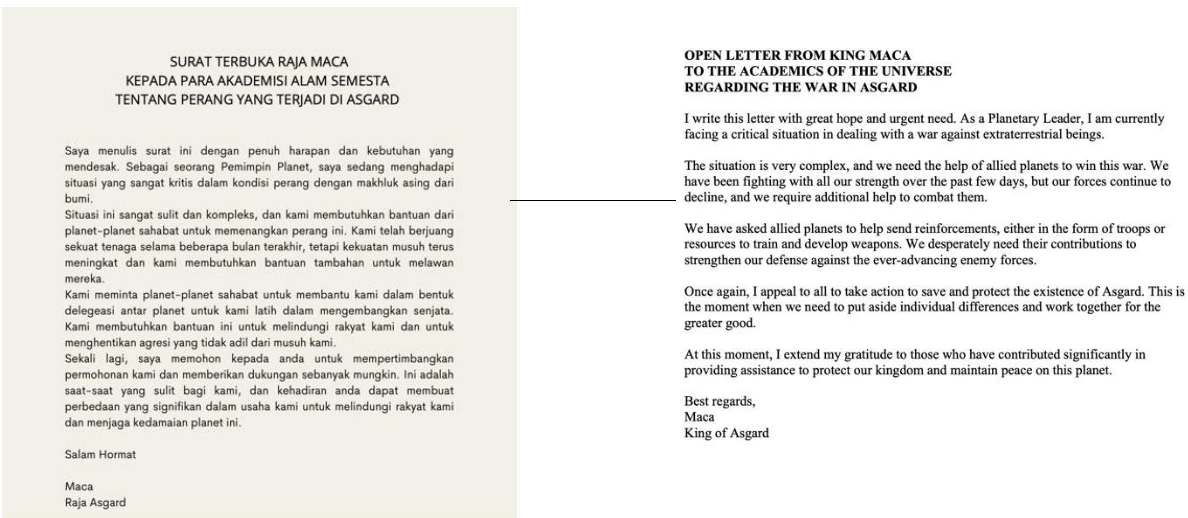
Figure 3. (a) Computer Display, (b) Smartphone Display

Deciding the Motivational Elements

Based on the assessment of potential problems, it was known that students frequently used smartphones during teaching and learning activities, resulting in decreased learning participation. The school also has a WiFi network. As a result, the researcher decided to improve student participation by combining virtual reality gamification with the flipped classroom learning model. Students were encouraged to take part in pre- and post-class activities. Feedback was given when they performed well in each activity. The researchers gave students flexibility without forcing them to engage fully. Purpose, access, challenge, feedback, and collaboration were all motivational elements integrated into this project.

Matching Motivational Elements with Level 1 Gamification Mechanisms

In the basic level pre-class activities, researchers applied problems from the planet Asgard, which is abundant in natural resources. One day, alien creatures from Earth attacked the planet Asgard. Maca, King of Asgard, ordered the Minister of Defense to fight back. However, the Asgard army struggled to compensate for earth creatures' abilities during the resistance. Figure 4 depicts the King of Asgard's open letter to academics and researchers, requesting their assistance in developing weapons to combat earth invaders.



SURAT TERBUKA RAJA MACA
KEPADA PARA AKADEMISI ALAM SEMESTA
TENTANG PERANG YANG TERJADI DI ASGARD

Saya menulis surat ini dengan penuh harapan dan kebutuhan yang mendesak. Sebagai seorang Pemimpin Planet, saya sedang menghadapi situasi yang sangat kritis dalam kondisi perang dengan makhluk asing dari bumi.
Situasi ini sangat sulit dan kompleks, dan kami membutuhkan bantuan dari planet-planet sahabat untuk memenangkan perang ini. Kami telah berjuang sekuat tenaga selama beberapa bulan terakhir, tetapi kekuatan musuh terus meningkat dan kami membutuhkan bantuan tambahan untuk melawan mereka.
Kami meminta planet-planet sahabat untuk membantu kami dalam bentuk delegeasi antar planet untuk kami latih dalam mengembangkan senjata. Kami membutuhkan bantuan ini untuk melindungi rakyat kami dan untuk menghentikan agresi yang tidak adil dari musuh kami.
Sekali lagi, saya memohon kepada anda untuk mempertimbangkan permohonan kami dan memberikan dukungan sebanyak mungkin. Ini adalah saat-saat yang sulit bagi kami, dan kehadiran anda dapat membuat perbedaan yang signifikan dalam usaha kami untuk melindungi rakyat kami dan menjaga kedamaian planet ini.

Salam Hormat

Maca
Raja Asgard

OPEN LETTER FROM KING MACA
TO THE ACADEMICS OF THE UNIVERSE
REGARDING THE WAR IN ASGARD

I write this letter with great hope and urgent need. As a Planetary Leader, I am currently facing a critical situation in dealing with a war against extraterrestrial beings.

The situation is very complex, and we need the help of allied planets to win this war. We have been fighting with all our strength over the past few days, but our forces continue to decline, and we require additional help to combat them.

We have asked allied planets to help send reinforcements, either in the form of troops or resources to train and develop weapons. We desperately need their contributions to strengthen our defense against the ever-advancing enemy forces.

Once again, I appeal to all to take action to save and protect the existence of Asgard. This is the moment when we need to put aside individual differences and work together for the greater good.

At this moment, I extend my gratitude to those who have contributed significantly in providing assistance to protect our kingdom and maintain peace on this planet.

Best regards,
Maca
King of Asgard

Figure 4. A Letter to Academics

The pre-class activity supplies a narrative about training with rubber guns and concepts of elasticity, plastic, stress, strain, and young modulus. To achieve goals through instruction, feedback, and teamwork, the researchers educate the participants about the class regulations and the main activity. Trainee badges indicate successful completion of pre-class exercises before the deadline, followed by responses to questions posed by the teacher. A pre-class inquiry can be, "Based on what the guide has explained, what are elastic and plastic objects?" In addition to answering questions, students can ask questions in the discussion forum. The questioner is awarded a junior thinker badge, while the student who answers receives a pro trainer badge. Completing the pre-class reflection activity will help students be better prepared to discuss with their teacher and peers.

Classroom activities are carried out using a battle system between squads to foster collaboration. The battle consists of three rounds with varying difficulty levels to respond to the challenge. Students receive adventure badges as immediate feedback after completing the four-round challenge. Post-grade level (one) activities that address access, challenges, and quizzes are provided within a set time frame. The quiz is optional; students are free to complete it or not. Figures 6 and 7 show how students are awarded badges and points. Quizzes improve the experience of accessing additional learning opportunities, but students can take them. At the end of each week, the total number of points and badges earned will be displayed on the leaderboard in Figure 8. As a result, students can track their progress and compare it to their peers.

Matching Motivational Elements with Level 2 Gamification Mechanisms

The intermediate-level pre-class activity tells how a rubber weapon is created and designed. During the mission, students developed and applied Hooke's law equation to calculate the spring constant and potential energy of a spring. The one-step trainee badge and battle points are used to track the completion of pre-class learning exercises (feedback). Then, 100 battle points will be awarded to students who ask questions and complete the one-step of the junior thinker badge. Students who answer questions and complete the pro trainer badge (collaboration) one-step will earn 150 battle points.

In intermediate-level classroom activities, students recount the narrative reading material and identify questions in the discussion forum for the teacher to clarify (objective). Students who answer will be awarded 100 battle points, while those who ask will receive 50 (feedback). To achieve challenge and collaboration, students are given a three-session practicum in the school laboratory, which focuses on investigating Hooke's law equation to determine the spring constant and potential energy in single, series, and parallel circuits. Students will earn 300 battle points, 16 keys, and 15 gems as feedback.

Quizzes are given regularly during post-intermediate level activities to address access, challenge, and feedback. The quiz is optional, and students can choose whether or not to complete it. Those who complete the post-class activity will receive 400 battle points and a one-step senior adventure badge. Quizzes improve the experience of accessing additional learning opportunities, but participants can take them.

Matching Motivational Elements with Level 3 Gamification Mechanisms

High-level pre-class activities provide a story about the characteristics of an effective rubber weapon. Students examine the grids and prepare tools and materials for the practicum in the laboratory.

During activities in high-level classes, teachers review the tools and materials supplied by students. To overcome challenges and encourage teamwork, students are tasked with determining the constant of rubber springs and the potential energy of rubber springs placed individually, in series, and in parallel from three different colours of rubber. Then, they decide which composition is best suited for usage as a bullet in a rubber weapon. Answers are delivered as files and then uploaded to the designated column. As a result of completing the last adventure, players will receive 300 battle points, 16 keys, 15 gems, and a junior adventure badge. Furthermore, the final mission test is offered to evaluate the material of solid elasticity (challenge). Six hundred battle points, 100 keys, 100 gems, and the AI Physicist badge are awarded for completing the Asgard mission's final tests (feedback).

High-level post-class activities culminate in a farewell narrative. As proof of completing the Asgard rescue mission and creating an attractive and effective rubber gun bullet (feedback), students receive a certificate of participation. Students who want extra points can complete an optional bonus task (access).

Launching Gamification Design into Learning Activities

In this context, game principles and elements such as points, levels, challenges, rewards and competition are used to create a more fun and interactive learning experience for students (see appendix).

Launching Gamified Learning Activity Design into Virtual Reality

The non-immersive virtual reality technology used, which uses 360° images that can be clicked in all directions, aims to create a learning experience tailored to students' needs. See Table 3.

Table 3. Integration of Gamified Learning Activities into Virtual Reality

Narrative	Virtual Reality
Asgard is a planet abundant with natural riches and minerals. One day, aliens from Earth assaulted the planet Asgard. Maca, King of Asgard, ordered the defence minister to fight back. However, Asgard warriors found it impossible to compensate for the earth species' abilities during the resistance. Let us observe the activity on this planet. Almost the entire planet Asgard has been governed by earth creatures, which is terrible given other creatures' hunger. It appears that the king sent a letter. Let's fighters read it.	

Narration can guide users through a virtual reality experience by providing context and direction. It creates a deeper level of immersion, where the user feels completely involved in the story and visual environment. It also helps present information or learning concepts in an organised and easy-to-understand way through bullet points.

Launching Gamified Learning Activity Design into the LMS

Launching the gamified learning activity design into the LMS involves gradually integrating game features into the online learning platform. This process entails personalising materials and gamification strategies like points or awards. See Figure 5.

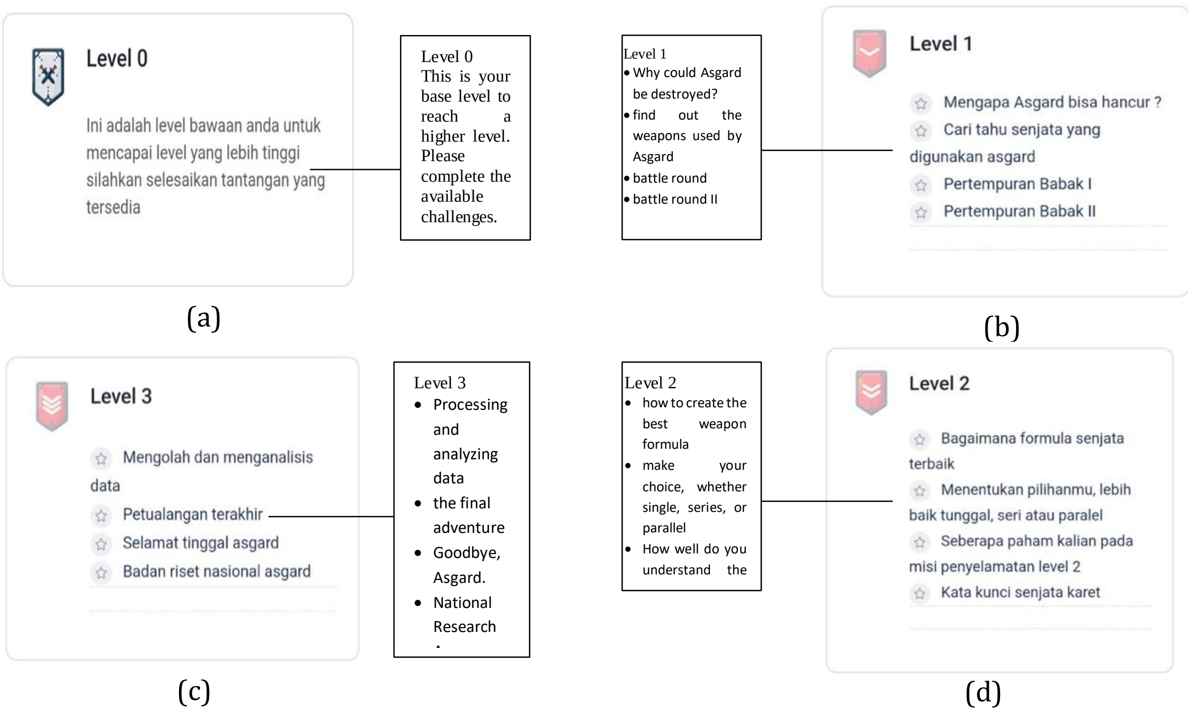


Figure 5. (a) Initial level, (b) Level 1, (c) Level 2, (d) Level 3

Levels are divided into four levels, with level 0 as the default level for newly registered students. Each level contains a mission that must be fulfilled. In Fisikawaii Adventure, points are classified into three types: key points, gems, and battle points. Key points are used to unlock further material. Gems can be redeemed for rewards and battle points to compete with their peers (see Figure 6).

Figure 6. Types of Points

The next game element is badges. Badges visually recognise students' achievement, participation, or success in learning activities (see Figure 7).

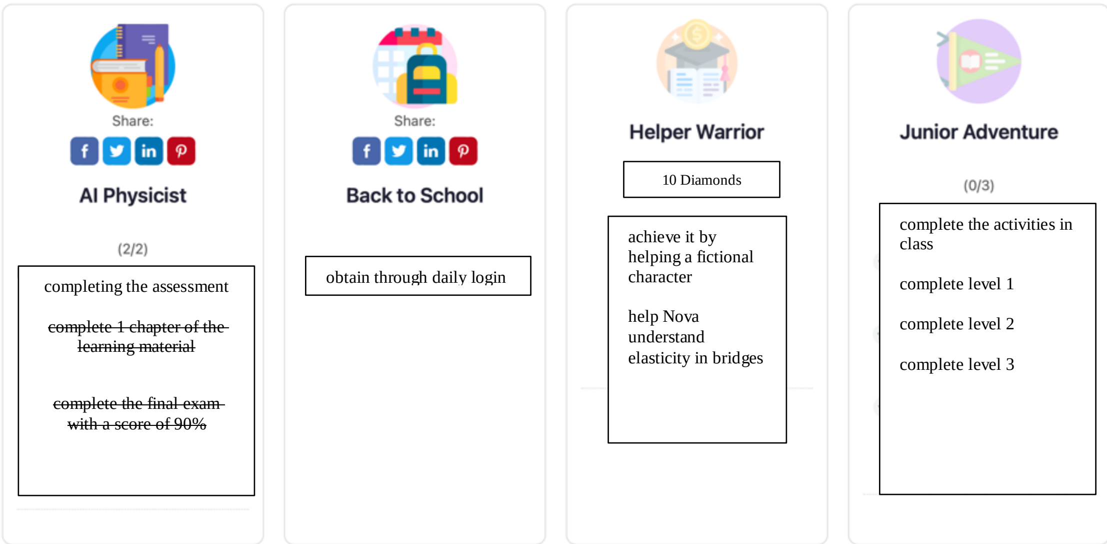
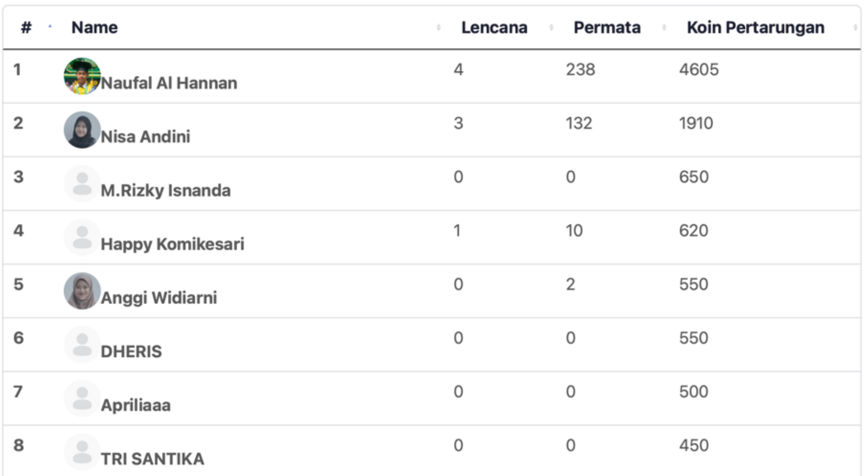


Figure 7. Types of Badges

There are 15 badges available in the Fisikawaii Adventure LMS. Earned badges are light in colour, whereas unearned badges are slightly opaque. Figure 8 shows how leaderboards can be integrated into the LMS to display and compare student achievement while increasing participation.



#	Name	Lencana	Permata	Koin Pertarungan
1	Naufal Al Hannan	4	238	4605
2	Nisa Andini	3	132	1910
3	M.Rizky Isnanda	0	0	650
4	Happy Komikesari	1	10	620
5	Anggi Widiarni	0	2	550
6	DHERIS	0	0	550
7	Apriliaaa	0	0	500
8	TRI SANTIKA	0	0	450

Figure 8. Leaderboard

Leaderboards provide insight into students' accomplishments and activities. Students may see how far they have progressed toward the learning objectives and where they stand compared to their peers. Leaderboards also let teachers monitor students' learning progress and participation. This allows the teacher to provide feedback or further support to students requiring additional assistance.

Launching Virtual Reality Design into LMS

The WP-VR plugin (see Figure 9) helped launch the virtual reality design into the LMS. This plugin allows virtual reality to be realised quickly. First, the researchers selected the 360° images, uploaded them to WP-VR, connected the scene, and added hotspots.

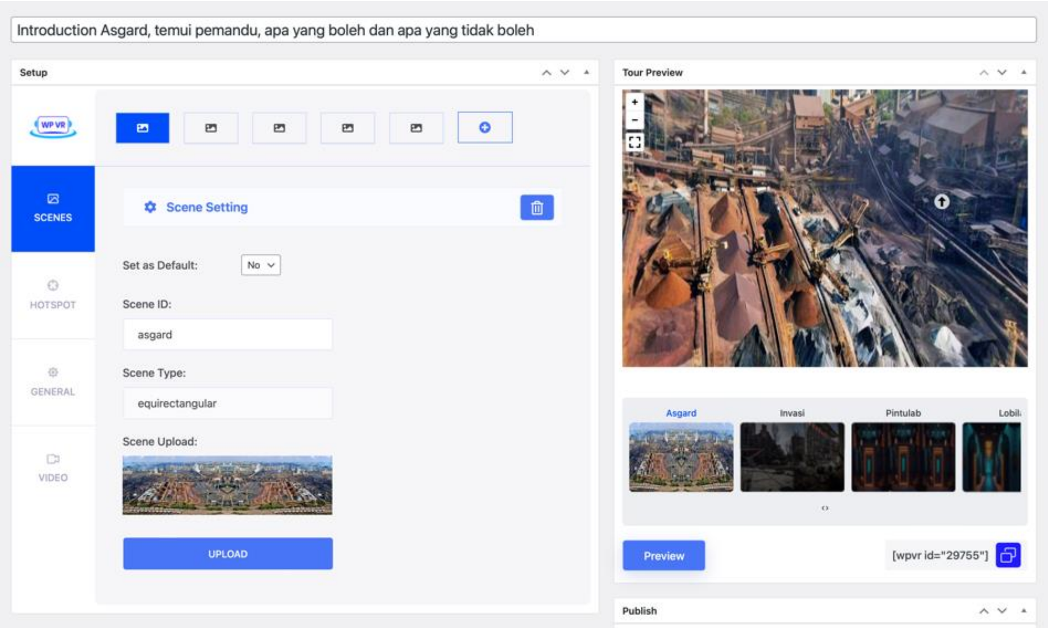


Figure 9. Virtual Reality and LMS Integration

The Feasibility of Fisikawaii Adventure LMS

The feasibility of the LMS was evaluated using formative evaluation. Material expert assessment includes content feasibility, presentation, language, and gamification. Media experts include aspects of software, user interface, user experience, and gamification. The results of the validity assessment can be seen in Table 4.

Table 4. The result of Validity

Validation	Aspect	Percentage	Average	Category
Material	Content Feasibility	86%	85,5%	Highly Feasible
	Language Feasibility	86%		
	Language Assessment	82%		
	Gamification Assessment	88%		
Media	Gamification Assessment	85%	87,25%	Highly Feasible
	User Interface	90%		
	User Experience	86%		
	Gamification Assessment	88%		

The validator's responses were positive in all aspects of the assessment. However, there were minor revisions related to the LMS. Revisions came from material experts related to formula writing and the addition of a bibliography. See Figure 10.

A rubber has an initial length of 50 cm and a cross-sectional area of 2 cm². When a force of 100 N is applied, the rubber stretches to a length of 60 cm. Calculate the stress experienced by the rubber.
Steps to calculate stress:
Organize the given data:

1. Initial length (L0L_0L0) = 50 cm
   Stretched length (LLL) = 60 cm
   Cross-sectional area (AAA) = 2 cm²
   Applied force (FFF) = 100 N
2. Calculate the change in length (ΔL\Delta LΔL):
   ΔL=L−L0=60 cm−50 cm=10 cm=0.1 m\Delta L = L - L_0 = 60 \, \text{cm} - 50 \, \text{cm} = 10 \, \text{cm} = 0.1 \, \text{m}ΔL=L−L0 =60cm−50cm=10cm=0.1m (in SI units)
3. Calculate the stress (TTT):
   Stress (TTT) is defined as the force (FFF) acting on an object per unit area (AAA).
   T=FAT = \frac{F}{A}T=AF
4. Substitute the given values into the formula:
   T=100 N2 cm2=50 N/cm2T = \frac{100 \, \text{N}}{2 \, \text{cm}^2} = 50 \, \text{N/cm}^2T=2cm2100N=50N/cm2

Thus, the stress experienced by the rubber is 50 N/cm250 \, \text{N/cm}^250N/cm2.

(a)

A rubber band has an initial length of 50 cm and a cross-sectional area of 2 cm². When a force of 100 N is applied, the rubber stretches to a length of 60 cm. Calculate the stress experienced by the rubber!
Steps to calculate stress:
Organizing the given data:

1. Initial length (L0L_0L0) = 50 cm
   Stretched length (LLL) = 60 cm
   Cross-sectional area (AAA) = 2 cm²
   Applied force (FFF) = 100 N
2. Calculating the change in length (ΔL\Delta LΔL):
   ΔL=L−L0=60 cm−50 cm=10 cm=0.1 m\Delta L = L - L_0 = 60 \, \text{cm} - 50 \, \text{cm} = 10 \, \text{cm} = 0.1 \, \text{m}ΔL=L−L0 =60cm−50cm=10cm=0.1m (in SI units)
3. Calculating the stress (TTT):
   Stress (TTT) is defined as the force (FFF) acting on an object per unit cross-sectional area (AAA).
   T=FAT = \frac{F}{A}T=AF
4. Substituting the given values into the formula:
   T=100 N2 cm2=50 N/cm2T = \frac{100 \, \text{N}}{2 \, \text{cm}^2} = 50 \, \text{N/cm}^2T=2cm2100N=50N/cm2

Thus, the stress experienced by the rubber is 50 N/cm250 \, \text{N/cm}^250N/cm2.

(b)

Figure 10. Formula Layout Improvements (a) Before Revision, (b) After Revision

Based on the validators' suggestions regarding the developed Fisikawaii Adventure LMS, the researchers revised it to improve the product's shortcomings. They added the WP QuickLatex plugin to overcome the formula writing issues.

Students' Response to Fisikawaii Adventure LMS

Students who participated in the limited trial showed positive responses to the LMS. They saw gamification technology and virtual reality as fun and interactive learning experiences. In addition, they felt immersed in the storyline presented. See Table 5.

Table 5. Students' Responses toward Fisikawaii Adventure LMS

Assessed Aspects	Validity (%)	Description
Learning	92%	Excellent
Material	93%	Excellent
User Interface	93%	Excellent
Software	92%	Excellent

This research displays an LMS's design, development, and initial implementation with a gamification approach combined with virtual reality (Fisikawaii Adventure) to promote student participation. Gamification is one approach to increasing student participation (Mazarakis, 2021). Fisikawaii Adventure was designed to create an immersive experience with high involvement and participation in learning. Regardless of manner, student participation should be for educational purposes (Ahlfeldt et al., 2005). To do so, the students' profiles and the existing educational facilities must be considered (Da Rocha Seixas et al., 2016). This study revealed that achieving goals in the attitudinal (motivation and interest), cognitive (understanding and thinking), conceptual (knowledge and concepts), and instrumental (skills and application) aspects, when aligned with educational goals, can act as a strong participation factor in learning (Da Rocha Seixas et al., 2016).

In contrast to the previous research's design approach for generating virtual reality gamification (Roshanpour & Nikroo, 2022), the Fisikawaii Adventure design framework is based on GAFFCC's five-stage design framework and motivational features(Huang & Hew, 2018). The design framework and motivating elements can help developers learn more about the alignment of gamification aspects, motivational factors, and learning objectives. Similarly, (Schöbel et al., 2020) advocate for integrating extensive theoretical basis and user expectations. Adding incentive features without a clear rationale can squander students' time (Morschheuser et al., 2018). As a result, this research can help practitioner gamification developers understand how to integrate gamification components, theories, and instructional goals.

Overall, this study found that virtual reality gamification had a favourable impact on learners. Badges (for example, senior adventure badges) are used in games to remind students that completing assignments before the deadline is the intended outcome. This is consistent with the assumption that creating meaningful goals in learning might boost students' motivation to complete the intended task (Da Rocha Seixas et al., 2016). Previous studies have shown that when learners are given clear and precise goals, such as completing quizzes on Moodle, they will be awarded badges. As students gain badges, their involvement improves (Imran, 2019).

Badges give learners positive feedback if they complete activities on time. They reinforce their conduct by indicating that they have achieved their goals. According to Uanhoro & Young (2022), such feedback serves as positive reinforcement, increasing the likelihood of repeating the behaviour. Our findings also suggest that positive feedback leads to higher-quality work.

Gamified learning allows learners to face a variety of problems. Although several skill levels are available, students can choose the level of effort that is most comfortable for them, such as in each post-class quiz from level 1 (remembering and understanding) to level 3 (evaluating and creating). This allows learners to exercise autonomy (Sailer et al., 2017). According to self-determination theory, meeting the desire for autonomy might improve intrinsic motivation to complete a task (Dunn & Zimmer, 2020). This approach is also consistent with the accomplishment need theory, which claims that most people seek out new challenges (McClelland, 1961), resulting in emotions of competence.

Virtual reality is an excellent way to engage students in a real-world learning experience. The tale will be conceptualised using 360-degree pictures, allowing students to immerse themselves in it. Garcia's assertion (Garcia-Marquez & Bauer, n.d.) that narrative is rarely examined in gamification research implies that further research is needed on how to build a story in gamification research.

Lin et al. indicated that virtual reality elements such as immersion, interactivity, immediacy, aesthetics, and presentation rigour promote cognitive benefits, affecting engagement and learning effectiveness (Lin et al., 2020). The researchers may claim that the findings of this research suggest that learners who learned using Fisikawaii Adventure LMS integrated gamification and virtual reality have greater levels of participation than learners who did not utilise Fisikawaii Adventure LMS. This finding is consistent with earlier research findings (Lin et al., 2020). Roshanpour and Nikroo found that gamification and virtual reality lead to better levels of motivation and involvement in sports learning, which is similar to the findings of this study (Roshanpour & Nikroo, 2022). Similarly, Sharhorodska discovered that gamified virtual reality environments increased learner interest and involvement in astronomy lectures (Sharhorodska, 2019).

Two validators, media and material experts, reviewed the feasibility of the Fisikawaii Adventure LMS. The evaluation findings suggest that the LMS is of excellent quality and appropriate for physics learning (see Table 4). Media experts evaluated the compatibility of software elements, user interface, user experience, and gamification design. Subject matter experts assessed instructional content, virtual reality presentation, language, and the balance of difficulties in gamification.

The design revision focused on correcting formula writing problems in the prior version. Formulas that were previously inaccurate or unclear have been modified with correct notation and simpler calculation processes (Figure 10). These improvements increase the design's quality and clarity, give a better user experience, and assure a deeper knowledge of the physics principles provided.

Students reacted positively to the LMS, making the learning experience more interesting and interactive (see Table 5). This favourable influence, in turn, promotes students' engagement in better learning the subject topic (Da Rocha Seixas et al., 2016). The study found that the graphical and aesthetic look met the user's expectations (see Table 5). This is reflected in the user-friendly navigation, intuitive layout, and visually appealing design. Learners appreciated how the design made it easy to access learning content, showed information clearly, and allowed for smooth interaction. The adaptable design and well-integrated features have resulted in a pleasing user experience, increasing the attractiveness and effectiveness of the Fisikawaii Adventure LMS in aiding learning. In addition, learners' appraisal of the learning objectives of Fisikawaii Adventure reveals that they are motivated to acquire more knowledge utilising the virtual reality integrated gamification technique, consistent with the previous findings (Škola et al., 2019).

From a pedagogical standpoint, this research helps to clarify the implementation environment and methods. Combining gamification and virtual reality into a flipped classroom format necessitates a high level of pedagogical, technological, psychological, and content knowledge. This study is a valuable resource for educators and practitioners unfamiliar with gamification and virtual reality to identify when and how to include them in learning activities. This study can assist them in understanding what elements may influence the implementation outcome by providing a complete description of the situation. The LMS implementation can be accessed via the link (www.fisikawaii.my.id)

LIMITATIONS

Although the overall findings of the research were mainly positive, some limitations should be noted. First, the study was limited to a single institution with a small sample size. As a result, the generalizability of the research results must be considered with caution. Nonetheless, the sample and location used in this research were enough to evaluate educational interventions. However, the researchers will take advantage of the opportunity offered by the limitations to conduct further research. In other words, future research will use larger sample sizes and diverse disciplines to better understand the combination of virtual reality and gamification. The researchers also recommend that the LMS be improved by considering user expectations.

CONCLUSION

The researchers showcased how Fisikawaii Adventure, a gamification and virtual reality integrated LMS, was designed and implemented to improve students' participation. This research employs the ADDIE development model in a step-by-step approach to analyse, design, develop, implement, and evaluate the LMS. The five-stage design framework and GAFCC (goal, access, feedback, challenge, and collaboration) motivational factors were applied during the design stage. The evaluation involved 10 grade XI MIPA students from SMA Negeri 2 Bandar Lampung who participated in the trial.

The findings indicate that the creation of the LMS went through various stages. The processes included curriculum analysis, learner context, and technology affordability assessment. The primary goal of Fisikawaii Adventure is to improve student learning participation by including them in missions and challenges. Goal motivation, access, feedback, challenge, and collaboration were utilised to accomplish this purpose. Furthermore, the gamification components of stages, missions, challenges, points, leaderboards, progress meters, and narration were utilised. The third phase synchronises the gamification design into learning activities with virtual reality. The Fisikawaii Adventure is an effective way to enhance student participation. Feasibility is determined by material and media evaluation. The material experts scored 85.5% in the highly feasible category, whereas media experts gave an average score of 87.25%. The Fisikawaii Adventure received a very favourable response from students, with a percentage score of 86.4% in the highly practical category. Students showed high interest and passion in following the missions and challenges offered.

The outcome is that this research can help educators and practitioners understand how to include gamification and virtual reality in physics education. The use of emerging technologies in learning is gaining popularity, and this research adds to our understanding of how gamification and virtual reality can facilitate learning. Furthermore, considering the prospective benefits of gamification and virtual reality in education, the research advises expanding its use. To achieve this goal, additional experimental investigations with more participants and longer periods are recommended to increase the statistical significance of the findings. This study recommends that educators use the Fisikawaii Adventure LMS to enhance learning participation.

AUTHOR CONTRIBUTIONS

MVAF, AW, and AS conducted a study on designing and drafting an article. NA, SS, and BMF developed the Fisikawaii Adventure. All researchers read and approved the final draft of the article.

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REFERENCES

Ahmed, H. D., & Asiksoy, G. (2021). The effects of gamified flipped learning method on student's innovation skills, self-efficacy towards virtual physics lab course and perceptions. *Sustainability (Switzerland)*, *13*(18), 10163. https://doi.org/10.3390/su131810163

Ahlfeldt, S., Mehta, S., & Sellnow, T. (2005). Measurement and analysis of student engagement in university classes where varying levels of PBL methods of instruction are in use. Higher Education Research & Development, 24(1), 5–20. https://doi.org/10.1080/0729436052000318541

Aydin, B., & Demirer, V. (2022). Are flipped classrooms less stressful and more successful? An experimental study on college students. International Journal of Educational Technology in Higher Education, 19(1), 4-1. https://doi.org/10.1186/s41239-022-00360-8

Bazargani, J. S., Sadeghi-Niaraki, A., & Choi, S. M. (2021). Design, implementation, and evaluation of an immersive virtual reality-based educational game for learning topology relations at schools: A case study. *Sustainability (Switzerland)*, *13*(23), 13066 . https://doi.org/10.3390/su132313066

Bower, M., Lee, M. J. W., & Dalgarno, B. (2017). Collaborative learning across physical and virtual worlds: Factors supporting and constraining students in a blended reality environment. *British Journal of Educational Technology*, *48*(2), 407–430. https://doi.org/10.1111/bjet.12435

Branch, R. M. (2010). Instructional design: The ADDIE approach. In *Instructional Design: The ADDIE Approach*. Springer US. https://doi.org/10.1007/978-0-387-09506-6

Bucchiarone, A. (2022). Gamification and virtual reality for digital twins learning and training: architecture and challenges. *Virtual Reality and Intelligent Hardware*, *4*(6), 471–486. https://doi.org/10.1016/j.vrih.2022.08.001

Bully, C., Gery, J., Nafors, D., Gong, L., Despeisse, M., Johansson, B., & Billesø, M. B. (2020a). Increasing Eco-Efficiency Awareness for Ship Loading Process Using Virtual Reality and Gamification. *Advances in Transdisciplinary Engineering*, *13*, 167–178. https://doi.org/10.3233/ATDE200154

Bygstad, B., Øvrelid, E., Ludvigsen, S., & Dæhlen, M. (2022). From dual digitalisation to digital learning space: Exploring the digital transformation of higher education. *Computers and Education*, *182*. https://doi.org/10.1016/j.compedu.2022.104463

Camuñas-García, D., Cáceres-Reche, M. P., & Cambil-Hernández, M. de la E. (2023). Mobile game-based learning in cultural heritage education: a bibliometric analysis. In *Education and Training*, *65*(2), 324–339. https://doi.org/10.1108/ET-06-2022-0247

Chamorro-Atalaya, O., Durán-Herrera, V., Suarez-Bazalar, R., Nieves-Barreto, C., Tarazona-Padilla, J., Rojas-Carbajal, M., Cruz-Telada, Y., Caller-Luna, J., Alarcón-Anco, R., & Arévalo-Tuesta, J. A. (2023). Inclusion of metaverses in the development of the flipped classroom in the university environment: Bibliometric analysis of indexed scientific production in SCOPUS. *International Journal of Learning, Teaching and Educational Research*, *22*(10), 247–270. https://doi.org/10.26803/ijlter.22.10.14

Chang, Y. H., Lin, J. Y., & Lu, Y. Te. (2021). Enhancing the intention to preview learning materials and participate in class in the flipped classroom context through the use of handouts and incentivisation with virtual currency. *Sustainability (Switzerland)*, *13*(6), 3276. https://doi.org/10.3390/su13063276

Cortes, J. A., & Swanson, C. I. (2023). Using drosophila oogenesis in the classroom to increase student participation in biomedical research. *Methods in Molecular Biology (Clifton, N.J.)*, *2626*, 381–398. https://doi.org/10.1007/978-1-0716-2970-3_21

Da Rocha Seixas, L., Gomes, A. S., & De Melo Filho, I. J. (2016a). Effectiveness of gamification in the engagement of students. In *Computers in Human Behavior*, *58*, 48–63. https://doi.org/10.1016/j.chb.2015.11.021

Dermeval, D., Albuquerque, J., Bittencourt, I. I., Isotani, S., Silva, A. P., & Vassileva, J. (2019). GaTO: An ontological model to apply gamification in intelligent tutoring systems. *Frontiers in Artificial Intelligence*, *2*. https://doi.org/10.3389/frai.2019.00013

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining "gamification." *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, MindTrek 2011*, 9–15. https://doi.org/10.1145/2181037.2181040

Dunn, J. C., & Zimmer, C. (2020). Self-determination theory. *Routledge Handbook of Adapted Physical Education*, *55*(1), 296–312. https://doi.org/10.4324/9780429052675-23

Ekici, M. (2021). A systematic review of the use of gamification in flipped learning. *Education and Information Technologies*, *26*(3), 3327–3346. https://doi.org/10.1007/s10639-020-10394-y

Fernández, J. S. (2021). Towards the Development of Immersive Virtual Reality Games for Spatial Skills Training. *CEUR Workshop Proceedings*, *3082*, 90–97.

Garcia-Marquez, C., & Bauer, K. N. (2021). An examination and extension of the theory of gamified learning: The moderating role of goal orientation. *Simulation & Gaming, 52*(4), 407-434. https://doi.org/10.1177/1046878120958741

Girondini, M., Stefanova, M., Pillan, M., & Gallace, A. (2023). Speaking in front of cartoon avatars: A behavioral and psychophysiological study on how audience design impacts on public speaking anxiety in virtual environments. *International Journal of Human Computer Studies*, *179*. https://doi.org/10.1016/j.ijhcs.2023.103106

Hafizoglu, A., & Yerdelen, S. (2019). The role of students' motivation in the relationship between perceived learning environment and achievement in science: A mediation analysis. *Science Education International*, *30*(4), 251–260. https://doi.org/10.33828/sei.v30.i4.2

Huang, B., & Hew, K. F. (2018). Implementing a theory-driven gamification model in higher education flipped courses: Effects on out-of-class activity completion and quality of artifacts. *Computers and Education*, *125*, 254–272. https://doi.org/10.1016/j.compedu.2018.06.018

Hussain, S. (2023). A review of gamification under various users, fields & applications. *International Journal of Engineering Trends and Technology*, *771*(1), 330–339. https://doi.org/10.14445/22315381/IJETT-V71I1P229

Imran, H. (2019). Evaluation of awarding badges on Student's engagement in Gamified e-learning systems. *Smart Learning Environments*, *6*(1). https://doi.org/10.1186/s40561-019-0093-2

Iquira, D., Sotelo, B., & Sharhorodska, O. (2019). A gamified mobile-based virtual reality laboratory for physics education: Results of a mixed approach. *Communications in Computer and Information Science*, *1034*, 247–254. https://doi.org/10.1007/978-3-030-23525-3_32

Jääskä, E., Lehtinen, J., Kujala, J., & Kauppila, O. (2022). Game-based learning and students' motivation in project management education. Project Leadership and Society, 3, 100055. https://doi.org/https://doi.org/10.1016/j.plas.2022.100055

Jiang, J., & Fryer, L. K. (2023). The effect of virtual reality learning on students' motivation: A scoping review. *Journal of Computer Assisted Learning, 40*(1), 360-373. https://doi.org/10.1111/JCAL.12885

Kapp, K. (2012). *The gamification of learning and instruction: Game-based methods and strategies for training and education. San Francisco, CA: Pfeiffer*.

Kern, F., Winter, C., Gall, D., Kathner, I., Pauli, P., & Latoschik, M. E. (2019). Immersive virtual reality and gamification within procedurally generated environments to increase motivation during gait rehabilitation. *26th IEEE Conference on Virtual Reality and 3D User Interfaces, VR 2019 - Proceedings*, 500–509. https://doi.org/10.1109/VR.2019.8797828

Khaldi, A., Bouzidi, R., & Nader, F. (2023). Gamification of e-learning in higher education: a systematic literature review. Smart Learning Environments, 10(1). https://doi.org/10.1186/s40561-023-00227-z

Kooloos, J. G. M., Bergman, E. M., Scheffers, M. A. G. P., Schepens-Franke, A. N., & Vorstenbosch, M. A. T. M. (2020). The effect of passive and active education methods applied in repetition activities on the retention of anatomical knowledge. *Anatomical Sciences Education*, *13*(4), 458–466. https://doi.org/10.1002/ase.1924

Larsen, J. D., Jensen, R. O., Pietersen, P. I., Jacobsen, N., Falster, C., Nielsen, A. B., Laursen, C. B., Konge, L., & Graumann, O. (2023). Education in focused lung ultrasound using gamified immersive virtual reality: A randomised controlled study. *Ultrasound in Medicine and Biology*, *49*(3), 841–852. https://doi.org/10.1016/j.ultrasmedbio.2022.11.011

Li, J., Wider, W., Ochiai, Y., & Fauzi, M. A. (2023). A bibliometric analysis of immersive technology in museum exhibitions: exploring user experience. Frontiers in Virtual Reality, 4. https://doi.org/10.3389/frvir.2023.1240562

Libriandy, E., & Arlini, P, M. (2020). Immersive virtual reality and gamification evaluation on treadmill exercise by using electrophysiological monitoring device. *ACM International Conference Proceeding Series*, 191–195. https://doi.org/10.1145/3429551.3429553

Lin, Y., Wang, G., & Suh, A. (2020). Exploring the effects of immersive virtual reality on learning outcomes: A two-path model. *In D. D. Schmorrow & C. M. Fidopiastis. Augmented Cognition. Human Cognition and Behavior 12197, 86–105. Springer International Publishing.* https://doi.org/10.1007/978-3-030-50439-7_6

Markina, E., & Mollá, A. G. (2022). The effect of a teacher-centred and student-centred approach on students' participation in the English classroom. *Bellaterra Journal of Teaching and Learning Language and Literature*, *15*(3), 2-11. https://doi.org/10.5565/rev/jtl3.1007

Martín-Gutiérrez, J., Mora, C. E., Añorbe-Díaz, B., & González-Marrero, A. (2017). Virtual technologies trends in education. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(2), 469–486. https://doi.org/10.12973/eurasia.2017.00626a

Mas, A., Ismael, I., & Filliard, N. (2019). Indy: A virtual reality multi-player game for navigation skills training. *2018 IEEE 4th VR International Workshop on 3D Collaborative Virtual Environments, 3DCVE 2018*, *March*, 1–4. https://doi.org/10.1109/3DCVE.2018.8637113

Makransky, G., Terkildsen, T. S., & Mayer, R. E. (2019). Adding immersive virtual reality to a science lab simulation causes more presence but less learning. *Learning and Instruction*, *60*, 225–236. https://doi.org/10.1016/j.learninstruc.2017.12.007

Mazarakis, A. (2021). Gamification reloaded current and future trends in gamification science. *I-Com*, *20*(3), 279–294. https://doi.org/10.1515/icom-2021-0025

McClelland, D. C. (1961). *The achieving society van nostrand Reinhold.* Princeton, N.J.

Michael H. W., Paul L. W., & Sadiman, A. (1991). *Metode dan analisis penelitian mencari hubungan* (2nd ed.). Erlangga.

Morschheuser, B., Hassan, L., Werder, K., & Hamari, J. (2018). How to design gamification? A method for engineering gamified software. *Information and Software Technology*, *95*, 219–237. https://doi.org/10.1016/j.infsof.2017.10.015

Nurulsari, N., Viyanti, V., & Yassine, B. (2023). HOTS-oriented student worksheets with blended learning: Improving students' science process skills. *Online Learning In Educational Research*, *3*(1), 47-58. https://doi.org/10.58524/oler.v3i1.228

Olimovna, M. G. (2023). The role of digital educational technologies in teaching physics. Science And Innovation International Scientific Journal, 2(4), 211-216. https://doi.org/10.5281/zenodo.7824362

Ozcinar, Z., Orekhovskaya, N. A., Svintsova, M. N., Panov, E. G., Zamaraeva, E. I., & Khuziakhmetov, A. N. (2021). University students' views on the application of gamification in distance education. *International Journal of Emerging Technologies in Learning*, *16*(19), 4–15. https://doi.org/10.3991/ijet.v16i19.26019

Patsaki, I., Dimitriadi, N., Despoti, A., Tzoumi, D., Leventakis, N., Roussou, G., Papathanasiou, A., Nanas, S., & Karatzanos, E. (2022). The effectiveness of immersive virtual reality in physical

recovery of stroke patients: A systematic review. *Frontiers in Systems Neuroscience*, *16*(September), 1–8. https://doi.org/10.3389/fnsys.2022.880447
Pinto, R. D., Peixoto, B., Melo, M., Cabral, L., & Bessa, M. (2021). Foreign language learning gamification using virtual reality—a systematic review of empirical research. *Education Sciences*, *11*(5), 222. https://doi.org/10.3390/educsci11050222
Puspitarini, Y. D., & Hanif, M. (2019). Using learning media to increase learning motivation in elementary school. *Anatolian Journal of Education*, *4*(2), 53–60. https://doi.org/10.29333/aje.2019.426a
Raja, R., & Nagasubramani, P. C. (2018). Recent trend of teaching methods in education" organised by sri sai bharath college of education dindigul-624710. *India Journal of Applied and Advanced Research*, *2018*(3), 33–35. https://doi.org/10.21839/jaar.2018.v3S1.165
Rohmah, L. A., Anggoro, B. S., & Gunawan, W. (2023). PDEODE strategy assisted by geogebra: Improving students' critical thinking and mathematical analysis. *Online Learning In Educational Research, 3*(1), 15-22. https://doi.org/10.58524/oler.v3i1.203
Roshanpour, R., & Nikroo, M. H. (2022). Investigating the impact of virtual reality and gamification on improving physical activities in school. *J Dep Anxiety Sci*, *1*(1), 1–08. https://doi.org/10.21203/rs.3.rs-47976/v1
Roslan, R., Ayub, A. F. M., & Roslan, R. (2022). *Blending gamification and virtual reality (VR) for Malaysian pre-school animal education.* In Perspectives and Practices of Gamification (pp. 113–136).
Sailer, M., Hense, J. U., Mayr, S. K., & Mandl, H. (2017). How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. *Computers in Human Behavior*, *69*, 371–380. https://doi.org/10.1016/j.chb.2016.12.033
Sharhorodska, O. (2019). Implementation of an immersive astronomy virtual laboratory bay using "gamification" techniques for high school students. *Proceedings of the LACCEI International Multi-Conference for Engineering, Education and Technology, 61, 24-26.* https://doi.org/10.18687/LACCEI2019.1.1.61
Schöbel, S., Janson, A., Jahn, K., Kordyaka, B., Turetken, O., Djafarova, N., Saqr, M., Wu, D., Söllner, M., Adam, M., Gad, P. H., Wesseloh, H., & Leimeister, J. M. (2020). A research agenda for the why, what, and how of gamification designs: Outcomes of an ecis 2019 panel. *Communications of the Association for Information Systems*, *46, 706–721*. https://doi.org/10.17705/1CAIS.04630
Schouten, D. G. M., Deneka, A. A., Theune, M., Neerincx, M. A., & Cremers, A. H. M. (2022). An embodied conversational agent coach to support societal participation learning by low-literate users. *Universal Access in the Information Society*, 22, *(1), 1215-1241*. https://doi.org/10.1007/s10209-021-00865-5
Škola, F., Tinková, S., & Liarokapis, F. (2019). Progressive training for motor imagery brain-computer interfaces using gamification and virtual reality embodiment. *Frontiers in Human Neuroscience*, *13, 1662-5161*. https://doi.org/10.3389/fnhum.2019.00329
Smaldino, S. E, Lowther, D. L, Russell, J. D. (2014). *Instructional technology & media for learning: Teknologi pembelajaran dan media untuk belajar*. Prenada Media.
Sökmen, Y. (2021). The role of self-efficacy in the relationship between the learning environment and student engagement. *Educational Studies*, *47(1), 19–37.* https://doi.org/10.1080/03055698.2019.1665986
Stylianou, V., & Savva, A. (2022). Learn-by-doing virtually; A gamified and metaverse design for group projects aiming at enhancing constructivist and collaborative learning. *AIS SIGED International Conference on Information Systems Education and Research 2022*, *129–141.* https://aisel.aisnet.org/siged2022/3
Sugiyono. (2014). *Metode penelitian kuantitatif, kualitatif dan R&D*. Alfabeta.
Tan, D. Y., & Cheah, C. W. (2021). Developing a gamified AI-enabled online learning application to improve students' perception of university physics. *Computers and Education: Artificial Intelligence*, *2*, 100032. https://doi.org/10.1016/j.caeai.2021.100032
Turan, M. (2021). Virtual reality implementation for University Presentation. *WSEAS Transactions on Systems and Control*, *16*, 696–704. https://doi.org/10.37394/23203.2021.16.63

Uanhoro, J., & Young, S. S. C. (2022). Investigation of the effect of badges in the online homework system for undergraduate general physics course. *Education Sciences*, *12*(3), 217. https://doi.org/10.3390/educsci12030217

Ulmer, J., Braun, S., Cheng, C.-T., Dowey, S., & Wollert, J. (2022). Gamification of virtual reality assembly training: Effects of a combined point and level system on motivation and training results. International Journal of Human-Computer Studies, 165, 102854. https://doi.org/https://doi.org/10.1016/j.ijhcs.2022.102854

Vieyra, R., Vieyra, C., Pendrill, A.-M., & Xu, B. (2020). Physics education gamified physics challenges for teachers and the public. *Physics Education*, *55 (4), 45014*. https://10.1088/1361-6552/ab8779

Wauck, H., Mekler, E. D., & Fu, W. T. (2019). A player-centric approach to designing spatial skill training games. *Conference on Human Factors in Computing Systems - Proceedings*, 66, 1–13. https://doi.org/10.1145/3290605.3300296

Werbach, K., & Hunter, D. (2012). *For the win: How game thinking can revolutionise your business.* Wharton Digital Press.

Yuningsih, Y. Y. A., Farida, F., & Pratiwi, D. D. (2021). Schoology-based e-learning: The impact on concepts understanding and mathematical communication abilities. *Online Learning In Educational Research, 1*(2), 81-92. https://doi.org/10.58524/oler.v1i2.60

Zainuddin, Z., Chu, S. K. W., Shujahat, M., & Perera, C. J. (2020). The impact of gamification on learning and instruction: A systematic review of empirical evidence. *Educational Research Review*, 30, 100326. https://doi.org/10.1016/j.edurev.2020.100326

Zhang, J. (2022). College English assisted teaching based on flipped classroom and its influence on students' learning psychology. *Occupational Therapy International*, 4723893, 10 *2022*. https://doi.org/10.1155/2022/4723893

APPENDIX

Table 6. Software Utilized

No	Software	Function
1	Google Chrome	Access the website dashboard
2	Safari	Access the website dashboard
3	Canva	Edit images in gamification media
4	Wordpress.org	Content Management System
5	Cloudflare	Provide access speed to website visitors
6	Plugin learnDash LMS	LMS
7	Plugin elementor pro	Make it easier to design a website
8	Plugin Elements Kit Pro	Additional design elements
9	Plugin video resume for learndash	Resume learning video
10	Plugin Essential Addon For Elementor	Additional design elements
11	Plugin BB Press	Create a discussion system
12	Plugin BuddyPress	Create a social media forum so students can create groups
13	Plugin Gamipress pro	Create a game system
14	Plugin Embed Press	Embed links in the subject matter
15	Plugin WP Rocket pro	Optimise the website database

Table 7. Level 1 Gamified Learning Activity

Time	Activities	Gamification Strategy	Motivational Elements
Pre-class	Accessing learning materials through technology (smartphones and	• Reward students with 120 battle points for	Goals Feedback Collaboration

Time	Activities	Gamification Strategy	Motivational Elements
	computers). Reading narration material: • Understand the mission • Meet the guide • What's allowed and what's not • Rubber weapon • Rubber weapon optimisation • Meet other fighters • Bring your gear Online Discussion	completing pre-class activities • Reward 100 battle points and unlock 1 step to earn the junior thinker badge for students who ask questions • Reward 150 battle points and unlock 1 step to the pro trainer badge for students who answer questions. • Reward the Helper Warrior badge and 10 gems for students who help Nova	
Whilst-class	Explain the narrative reading material, identify questions in the discussion forum, study the relationship between stress, strain, and modulus of elasticity, use hands-on practice, and summarise the learning.	• Reward students with 100 battle points for answering questions correctly and 50 for asking questions. • Reward students with 300 battle points and one key if they complete three rounds of practice questions and unlock two steps to earn the Junior Adventure badge.	Goals Challenge Feedback Collaboration
Post-class	Quiz	• Reward students with 400 battle points, 2 keys, and 2 gems, as well as unlock 1 step to earn the Senior Adventure badge.	Access Challenge Feedback

Table 8. Level 2 Gamified Learning Activity

Time	Activities	Gamification Strategy	Motivational Elements
Pre-class	Accessing learning materials through technology (smartphones and computers). Reading narration material: • The best weapon formula • Design and build • Meeting Other Warriors II Online Discussion	• Reward students with 100 battle points and unlock 1 step towards earning a trainee badge if they complete pre-class activities. • Reward 100 battle points and unlock 1 step to earning the junior thinker badge for students who ask questions.	Goals Feedback Collaboration

Time	Activities	Gamification Strategy	Motivational Elements
		• Reward 150 battle points and unlock 1 step to a pro trainer badge for students who answer questions.	
Whilst-class	Restate the narrative reading material, identify questions in the discussion forum, formulate Hooke's law equation to determine the spring constant and potential energy, hands-on practice, and summarise the learning.	• Reward students with 100 battle points for answering questions correctly and 50 for asking questions. • Reward students with 300 battle points, 16 keys, and 15 Gems, and unlock the 1-step Junior Adventure badge.	Goals Challenge Feedback Collaboration
Post-class	Quiz	• Reward students with 400 battle points and 10 keys and unlock 1 step to earn the Senior Adventure badge.	Access Challenge Feedback

Table 9. Level 3 Gamified Learning Activity

Time	Activities	Gamification Strategy	Motivational Elements
Pre-class	Accessing learning materials through technology (smartphones and computers). Reading narration material: • Apply data acquisition • National research agency Asgard • Prepare everything Online Discussion	• Reward students with 150 battle points, five gems, and five keys, and earn trainee badges.	Goals Collaboration
Whilst-class	Checking tools and materials, end-of-semester examinations, and hands-on practice.	• Reward students with 600 battle points, 100 gems, and 100 keys. As well as the AI Physicist badge, • Reward students with 300 battle points, 16 keys, and 15 Gems, and unlock the 1-step Junior Adventure badge.	Goals Challenge Feedback Collaboration
Post-class	Quizzes and creative project assignments.	• Reward students with 400 points, 50 gems, and 150 keys	Access Challenge Feedback