

The Effectiveness of Natural Science Learning Based on Gamification to improving Learning Outcomes

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Cite this paper as: Siti Muyaroah, Muhammad japar, Indina Tarjiah (2024) The Effectiveness of Natural Science Learning Based on Gamification to improving Learning Outcomes. *Frontiers in Health Informatics*, 13 (3),7711-7720

Abstract: *This study explores a science learning model that is gamified. Using a gamification-based learning management system (LMS), flipped education, Science, Environment, Technology, and Society (SETS), and Problem-Based Learning (PBL) arrived together to create this learning approach. The teacher sets up teams and discusses into the lesson's goals, the resources that will be covered, the media that will be utilized, and how they will be applied. Students work in teams to answer issues after the teacher organizes the pupils into six teams and went through the topic with them. Pupils use a variety of learning tools, including books, notebooks, the internet, and materials from their surroundings, when they collaborate as teams to solve challenges. During class, students collaborate to find solutions to the teacher's difficulties by having conversations with their teams. It turns out that pupils are affected differently by technology use. Pupils get excited and driven to study and comprehend the subject matter more fully. In Baturaja, Ogan Komering Ulu Regency, South Sumatra, Indonesia, the 7th grade junior high school students learned natural science online by gamification. Students who study with the scientific learning model are polled and critically evaluated at the conclusion of the semester. The results of the investigation demonstrate pupils learn more successfully in classes that apply the science learning model. Pupils not only have good learning outcomes but also have a strong will to learn and abilities to think critically. Furthermore, using this learning paradigm has a positive effect on pupil's capacity to share information. This occurs as a result of pupils' constant discussion and opinion-sharing with friends in teams and during class.*

Keywords: *Learning, Learning model, Science, Gamification, Educational games*

Introduction

Today's rapid technological progress began 30 years ago when the era of the massive electronic revolution began. Students born in 2000, also known as the millennial generation, are also known as digital natives (Prostova et al., 2021) and have unlimited resources because access to information is very broad. Technological developments also provide various conveniences for society, including in the field of education, both middle and high school. In conventional learning, teachers consider students empty glasses that must be filled (Dicky Agus Purnama & Lubis, 2023). Integrating learning by utilising technology expands and contributes to learning methods and changes the paradigm and patterns of student learning (Katsigiannakis & Karagiannidis, 2017; Yusri et al., 2021). However, the changes that occur due to the technological revolution require teachers to switch and develop conventional learning to technology-based learning (Katsigiannakis & Karagiannidis, 2017; Shute et al., 2021; Yusri et al., 2021) such as the use of multimedia and applications (Dicky Agus Purnama & Lubis, 2023; Prostova et al., 2021) E learning (Katsigiannakis & Karagiannidis, 2017), game-based learning (Shute et al., 2021; Yusri et al., 2021), fun learning (Kristianti & Harsono, 2023; Nabilah Mokhtar et al., 2023) and gamification (Caporarello et al., 2019; Fitria, 2023)

Learning natural sciences is the basis for important learning skills to develop the ability to make evidence-based decisions, critical thinking skills, and apply scientific reasoning to real life (Jampel et al., 2018; Lederman et al., 2013). The ability to think scientifically from science learning also influences students' involvement in developing science and technology (Lederman et al., 2013; Panjaitan et al., 2023). Curricula and learning models have been explored to improve the quality of science teaching and learning for many years. However, based on the results of research observations conducted on junior high school students in Baturaja, South Sumatra, Indonesia, it was found that students' learning abilities and motivation towards learning natural sciences needed to be stronger. The complexity of the material and concepts in natural science learning and the teacher's ability to manage the class to convey learning objectives create unpleasant learning experiences that reduce students' enthusiasm for learning science.

The transformation of learning models to increase students' interest and abilities in the field of natural sciences continues to be pursued in line with technological developments. In the early 2000s, Prof. Binadja from Indonesia introduced a learning model for science learning (Nawzad et al., 2018; Panjaitan et al., 2023). According to this model, the teacher is a facilitator, and students play a very active role in learning (González-Fernández et al., 2022). A learning model that is fun and student-centred by utilising information technology, where games and the internet have become icons of the digital generation. The new generation connects various platforms such as social media, online games, and chat rooms to obtain the information needed to fulfil their curiosity about things of interest (Bai et al., 2020; Baptista & Oliveira, 2019; González-Fernández et al., 2022). One of the interesting trends in education today is the gamification-based learning model. The application of gamification in education is starting to be developed by researchers and educators because several related studies have found an increase in students' interest in being actively involved in learning (Aguiar-Castillo et al., 2021; Costa & Aparicio, 2017; Oliveira et al., 2021). Gamification refers to applying game design aspects in nongaming contexts to increase engagement, motivation, and performance so that teaching and learning activities become more fun and interesting (Toimah et al., 2021; Zafar et al., 2022). The aspects adopted in the gamification-based learning model are interesting and innovative learning conditions, where students are free to develop and work together to achieve learning goals in the game context. Ultimately, they are given awards for learning achievements using points, medals, levels, and avatars, virtual currency and ranking achievements (Kalogiannakis et al., 2021; Rahmatiah et al., 2023). The application of natural science learning online based on gamification is inspiring to increase students' interest in learning; this research explains the effectiveness of natural science learning online based on gamification so that it can improve student learning outcomes.

The research questions that will be answered in this paper are:

1. What is the teacher's approach to natural science learning?
2. How is natural science learning online based on gamification implemented?
3. How effective is natural science learning online based on gamification?

This paper is planned as follows: related to the theory in Section 2. The methodology is presented in Section 3. Experimental and test results are given in Section 4. The paper is concluded in Section 6.

1. Literature Review

2.1. Science Environment Technology Society (SETS)

SETS is an acronym for science, environment, technology and society. Learning sets combine learning with the environment and technology. This is what millennials are experiencing today. They can access it anytime and are active on social media. SETS learning consists of 5 steps: initiation, development, concept application, implementation and evaluation (Setyo Retno & Marlina, 2018). Science learning requires discovery, either by observation or experiment, as scientific work. Through scientific work, students can utilise facts and build concepts as a basis for critical, creative and analytical thinking. The practical method used in learning by applying science process skills can make students trained and become skilled in expressing and developing the theories and concepts studied (Hikmah & Himawati, 2023).

2.2. Gamification

Gamification uses game-based mechanics, aesthetics, and game thinking to engage people, motivate action, promote learning, and solve problems (Kapp, 2012). It makes technology more engaging and encourages desired behaviour, exploiting humans' psychological predisposition to engage in games. Gamification is a process involving the selection, application, implementation, and integration of game design elements, not just their use (Mlumun et al., 2021; Zirawaga et al., 2017).

A range of contributions help to develop the concept of gamification. The implementation of game elements in a non-gaming setting is referred to as gamification (Hosny et al., 2021a). An alternative understanding focuses the role of gamification in integrating gaming activities to improve behavioral results by means of inspiring stimulation. In some situations, employing games can add excitement and inspiration to everyday activities (Krath et al., 2021). By improving the creation of value in service delivery through the use of gamification as a business approach or highlights components like engagement and solutions, this shows the crucial role use gamification in business (Buckley & Doyle, 2017). Gamification is referred to as "a combination of procedures and tasks for solving issues that involve education" and is used in classrooms. Gamification is the integration of fun game elements to solve actual-life issues in a gaming atmosphere. It is a blend of serious gaming and entertainment (Hosny et al., 2021b; Priyaadharshini et al., 2020; Sa et al., 2020; Zainuddin et al., 2019). So although definitions vary in their focus, they always contain experience elements that characterize user

activity and systemic elements that define how the game is built (such as the programming of game mechanics) and impacts the game (Johnson et al., 2017). As a result, gamification encourages actions that make learning more enjoyable, such as student motivation, involvement, teamwork, etc. That being said, other factors, such the learner's traits or the environment in which the game will be used, also affect how effective the game is (Byusa et al., 2022; Sjöberg & Brooks, 2022; Zainuddin et al., 2019) Four categories of users are identified based on their attention to action, interaction, games, and environmental factors: explorers (who want to understand the system), friendly (who love sharing), and killers (who want to win and others to lose) (Patricio et al., 2022)

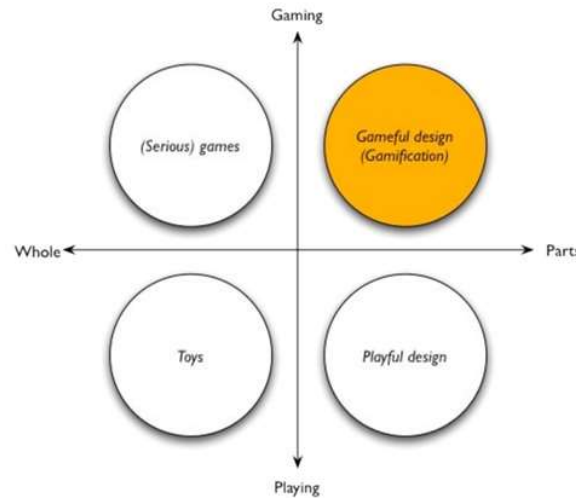


Figure 1. The Gap Between Game Applications and Gamification Figure 1 was created to facilitate understanding the concepts underlying gamification in learning. In Figure 2, toys and games are designed to be fun with predetermined rules. The game system has two parts, namely, game content and game elements.

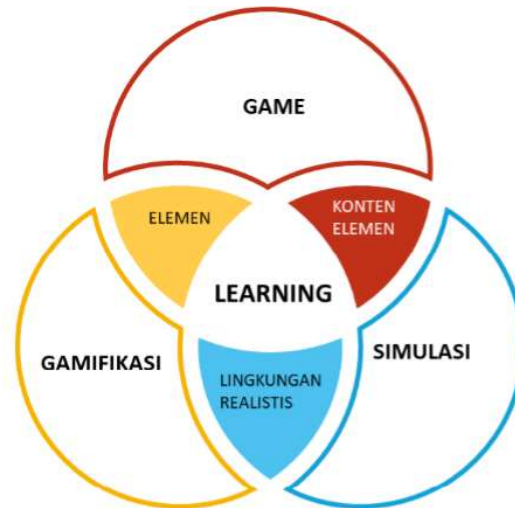


Figure 2. The Integration of Gamification, Game and Simulation The integration between games, gamification and simulation in learning is clearly illustrated in Figure 2. Three forms of games are included in integrating games into education: simulation, games and gamification. A gamification is an emerging approach to learning that facilitates learning and encourages motivation through the use of game elements, game mechanics, and game-based thinking. In gamification, students only play part of the game from start to finish. Rather, they participate in gameplay activities such as earning points, overcoming

challenges, or receiving badges for completing tasks.

2. 3. *Problem-Based Learning (PBL)*

By posing challenges they are interested in addressing, problem-based learning encourages students to use what they already know and inspires them to learn new information(ASLAN, 2021). Problem-Based Learning offers students the chance to acquire a range of problem-solving competencies, such as how to create strategies to identify problems (analysis), frame problems (organization), and solve problems (application, synthesis), in addition to promoting learning connected to academic content standards. The Problem-Based Learning methodology enables students to apply information consciously and recognize the connection between what they learn in school and the outside world, as indicated by the introductory scenario. With the help of the problem-based learning model, which is an active learning approach, students can improve their problem-solving abilities, become competent in academic subject areas, and recognize the importance of applying content area learning for practical purposes(Milman & Kilbane, 2013).

The problem-based learning model should use authentic problems, which are real-world issues that are significant to students as well as the teacher, appropriate in size and scope, and that pique their curiosity. The goal of project-based learning is to increase student participation in the educational process by organizing the curriculum around the completion of meaningful projects or assignments(Khoiriyah & Husamah, 2018; Waite et al., 2020)The goal of problem-based learning is to identify a solution. The purpose of project-based learning is completing a project. Problem-solving can additionally be a part of collaborative learning experiences; in this situation, problem-based learning will be integrated into the learning process. The most effective method for teaching young people how to solve actual issues, develop independent learning, and help them improve their critical, cooperative, and collaborative thinking skills is through the use of the problem-based learning model(Milman & Kilbane, 2013). The following are the rules carried out by students and teachers in the problem-based learning model(Milman & Kilbane, 2013)

Table 1. Teacher and Student Roles in the Problem-Based Learning Model

Problem-based learning model steps	Teacher Role	Student Role
Present or identify the problem	The educator asks the learners to identify an issue or gives them a "good" problem to investigate. The teacher chooses how to organize the learners into groups in each scenario. In this stage, the instructor have to provide the learners with a list of the projects and a schedule for finishing them	The teacher presents an issue, and the pupils investigate. In certain cases, the pupils might pinpoint the issue.
Develop a plan for solving the problem.	Students are asked to create a strategy for resolving the issue by the teacher. In order to support learners in carefully analyzing the scenario and coming up with a solution plan, she or he might need to pose probing questions. When the educator proposes or requests learners form teams to solve an issue, the educator must support how the pupils learn by offering structure for how they can create their plans.	The pupils create a logical strategy for resolving the issue. This should ideally happen in a team setting so pupils may discuss and decide on a plan of action.
Implement the plan	Students are asked to execute on their strategy by their instructor. The instructor might have given more assistance, including assisting students in capturing or reporting the execution of their strategies so they can review them in their next step.	The pupils put their strategies into practice or evaluate them. They should document the results of their strategy and what occurred.
Evaluate the implementation	Students are asked to assess and consider their strategies for execution and results by the teacher. Pupils should be asked about the ways they participated to the solution-finding procedure personally and in teams,	Learners assess and consider how their plans were carried out as well as the results. They should to consider how they individually as well as collectively participated to the

as well as any changes they could have contributed. The educator can also assist pupils in evaluating the advantages and difficulties of other methods for resolving the same issue.

2. Method

Online natural science learning is designed and implemented using a Learning Management System (LMS) in the learning process. The learning model places the teacher as a facilitator in the learning process. The entire learning process is shown in Figure 3. The research was conducted in grade 7th Junior High Schools in Baturaja City, Ogan Komering Ulu Regency, South Sumatra, Indonesia, to determine the effectiveness of natural science learning online based on gamification. Effectiveness was obtained from the results of assessing student understanding using tests. Meanwhile, the level of student satisfaction with learning media was determined by administering questionnaires.

2.1 Participants

Participants in this study were 7th-grade Junior High School students. The trial's selection of classes was based on the results of discussions with science teachers. The class chosen is heterogeneous in terms of academic ability and gender.

2.2 Instrument

A pre-test and post-test were conducted to measure the impact of implementing the natural science learning model. Before the test items are used, their validity and reliability are first calculated. The test items' reliability was measured using Cronbach's Alpha calculations. The natural science learning model's based on gamification effectiveness was measured by calculating the t-test and the N-Gain Score value. The following are the results of reliability statistical calculations using Cronbach's alpha.

Table 2. Results of the Alpha's Cronbach test of reliability

Reliability Statistics	
Cronbach's Alpha	N of Items
0,852	22

The results of the reliability test calculations are shown in Table 1. Of the 22 questions that were declared valid, when the reliability test calculation was carried out, they were also declared reliable. This is because the Cronbach's Alpha value was > 0.6. After the question items are declared valid and reliable, the questions can be used to measure students' abilities. **Result**

A learning model cycle is established by dividing the research stage into several consecutive steps. In Step 1, at the beginning of the lesson, the teacher explains the learning objectives and the material to be studied. The teacher also explains the media that will be used to support the learning process. As seen in Figure 3, the teacher uploads material to the LMS, which will be used as learning support media.

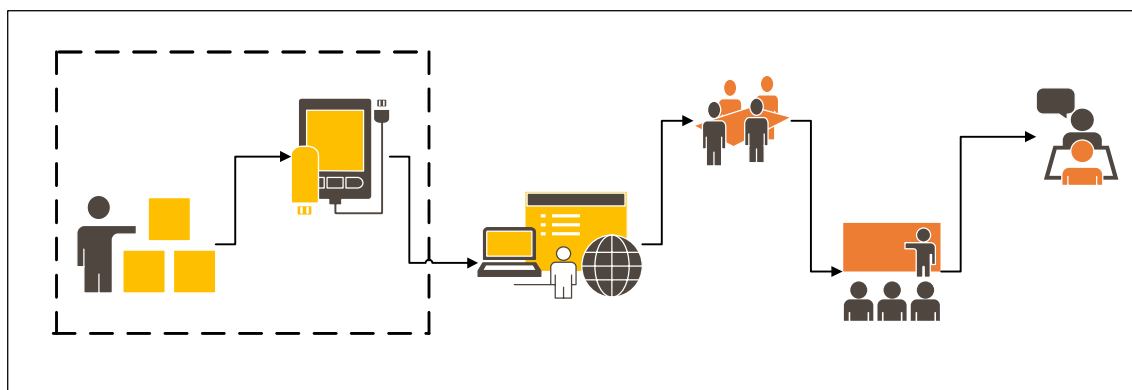


Figure 3. Natural Science Learning Model Based on Gamification n step 2, the teacher

also divided the class into six teams and gave problems to be solved by each team. Each team works together by looking at the material in the LMS and can also look for material from other sources that can be used through books, journals, or other sources. Once it is felt that the resources each group has are sufficient, the group will faithfully solve the problems the teacher gave. Step 3: each group presents the results of their group discussion. Other groups listen and provide input for the group presenting to improve results. Step-4, At the end of the lesson, the teacher clarified if there were groups that were not suitable for solving problems and gave prizes to the best groups. Giving prizes is intended to motivate students to learn.

Implementing a natural science learning model based on gamification significantly improves student learning outcomes. This can be seen in Figure 4, where pupils learning using a natural science learning model based on gamification get much better results than those learning not using a natural science learning model based on gamification. This aligns with what was conveyed by students in the questionnaire filled out learning using learning models assisted by online learning media, which made students more curious and motivated to learn. Apart from that, ICT-based media also allows students to learn more flexibly because learning can be done anywhere and at any time.

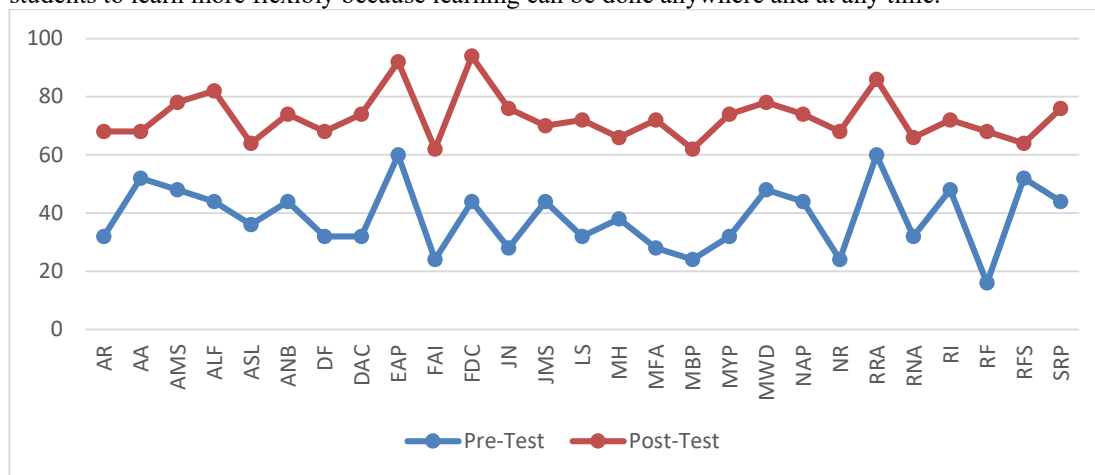


Figure 4 Comparison of scores before and after using a gamification-based science learning model A t-test was carried out to determine the effectiveness of the natural science learning model based on gamification. The following is the t-test calculation:

Table 3. Results of paired sample test of effectiveness

		Paired Differences				t	df	Sig. (2-tailed)	
Pair	pretest	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
1	posttest	-34,296	9,555	1,839	-38,076	-30,517	-18,651	26	0,000

Based on the t-test calculation table above, it can be concluded that there is a significant difference in the average learning outcomes before and after using the natural science learning model based on gamification. This can be seen from the results of the t-test calculations where t-count > t-table, the t-count value is 18.65 > 0.6, and the significance value (2-tailed) < 0.5, namely 0. This indicates that the natural science learning approach based on gamification has a major impact on student learning results. Apart from using the t-test to determine the effectiveness of natural science learning model based on gamification, here is the N-Gain calculation

Table 4. Results of N-Gain Score

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
N-Gain_score	27	.25	.89	.5583	.12761
N-Gain_percent	27	25.00	89.29	55.8316	12.76109
Valid N (listwise)	27				

Based on the calculation of the N-Gain score distribution table, the natural science learning model based on gamification received a score of 0.56, so it is included in the "medium" classification; meanwhile, in the N-Gain effectiveness interpretation category, there is an increase in students' understanding of the learning material. It can be seen that the N-Gain percentage value is 56%, so the gamification-based science learning model is declared quite effective in improving student learning outcomes.

3. Discussion

The main aim of this research is to determine the effectiveness of the natural science learning model based on gamification. The effectiveness of the learning model is tested based on students' understanding scores before and after using it. Based on t-test calculations and N-Gain values, students' understanding increases before and after using the learning model. The t-test calculation shows a significant difference in student learning outcomes, while the N-Gain calculation shows that the natural science learning model based on gamification is quite effective in learning.

The use of learning support media can be one of the reasons for increasing students' understanding of learning. This happens because using technology-based learning media gives students more freedom to learn. The model syntax also allows students to experience improvements in understanding learning. This happens because students are allowed to explore knowledge by exploring the subject matter provided independently so that students are given the freedom to learn according to their abilities. Apart from students exploring learning material, group work is also quite effective for students to exchange ideas and make corrections. In addition, providing direct learning experiences involving students' active learning and enjoyable learning situations can increase students' understanding (joyce et al., 2015).

4. Conclusion

The use of natural science learning model based on gamification significantly influences student learning outcomes. This can be seen from the calculation results in Table 2 and Table 3 regarding the results of effectiveness test calculations and N-Gain calculations. It can be concluded that the application of the natural science learning model based on gamification is quite effective in learning. The use of technology-based learning media in implementing the natural science learning model based on gamification gives students more freedom to explore their potential and deepen the subject matter provided in the Learning Management System used and other learning sites that support learning. Apart from that, this learning model also requires students to work in groups so that they can exchange ideas, improve their communication skills, and think critically about solving problems given by the teacher. Because learning provides a direct experience to students so that learning becomes fun and enhances student learning outcomes

Apart from that, the limitation of this research is that the school did not permit students to bring gadgets/smartphones to school, so researchers needed help in the research process. Apart from that, when students study at home, the internet connection in every area where students live could be more stable. To overcome this, researchers collaborate with the school to use existing learning facilities at the school, both computer laboratories and science laboratories, to support learning.

This research can be used as a reference for future researchers to increase students' understanding of the field of science. According to the results of our research, a natural science learning model based on gamification can be more effective if learning uses computer-based learning media. This happens because, currently, students prefer to learn using computer-based media or information and communication technology.

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