



ENHANCING STUDENT PERFORMANCE IN STEAM THROUGH GAMIFICATION: A SWOT ANALYSIS

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ABSTRACT

Teungku Chik Pante Kulu Secondary School examines how well gamification-based education strategies can be incorporated into STEAM (science, technology, engineering, arts, and mathematics) education. The teacher uses Scratch to assess how gamified learning affects student performance and engagement in this particular educational setting using a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis approach. The study highlights the potential benefits of gamification in STEAM education, including increased student engagement, improved problem-solving abilities, and collaborative learning opportunities catered to the needs of Teungku Chik Pante Kulu students. It does, however, also recognize the difficulties, such as the necessity for teachers to have proper training and resources, as well as any potential issues with sustainability and long-term effects. Furthermore, by taking into account the particular cultural and contextual characteristics of Teungku Chik Pante Kulu Secondary School, the analysis identifies chances for utilizing gamification to satisfy particular learning goals and curriculum requirements. On the other hand, risks like technology limitations and the requirement for ongoing assistance and assessment systems are also covered concerning the educational setting. Through an examination of gamification in the unique context of Teungku Chik Pante Kulu Secondary School, this study provides insightful information for teachers and administrators looking to improve student engagement and performance in STEAM subjects through creative teaching strategies. With the ultimate goal of enabling educators to design engaging learning experiences, this study adds to the expanding corpus of research on successful teaching tactics catered to varied learning settings.

Keywords: gamification, steam education, swot analysis, secondary school, Scratch

1. INTRODUCTION

Education development is a principal aspect of student growth processes, plays a crucial role in shaping the future of individuals and societies, and delivers a good impact on the sustainability of schools (Saputra et al., 2019; Saputra et al., 2024). Advancements in education not only enhance knowledge and skills but also foster critical thinking, creativity, and innovation (Gupron et al., 2021; Saputra & Siregar, 2022). Many schools implemented STEAM (Science, Technology, Engineering, Art, and Math) concepts in their curriculum to improve and enhance student knowledge and skills. This is, of course, aligned with the Indonesian government's demand that every educational unit utilize the Merdeka curriculum (named Kurikulum Merdeka) in its education system, which 143,265 have already implemented (Isaeni, N. & Nugraha, A., 2022) with more than 10.2 million users of digital educational platforms in 2022 (Madrim, 2022). The implementation of STEAM is also in high-level demand where the high school is dominated with 42.2% in Figure 1 (Farwati et al., 2021). This became a reason also carried out by Teungku Chik Pantekulu Darussalam Secondary School, which uses the same approach in its curriculum, even though as an educational unit that was only established in 2020, it does not yet use the Merdeka Curriculum.

Gamification is the use of game design elements, tools, methods, or principles in non-game contexts, such as education, to increase motivation, participation, and enjoyment to generate better impact for users/students (Arlinwibowo et al., 2023; Saputra et al., 2024). Gamification can contain many elements such as points, badges, leaderboards, levels, rewards, feedback, challenges, and narratives. Gamification can also involve applying game



mechanics, such as rules, goals, competition, cooperation, and interactivity, to create a more immersive and fun learning experience (Prieto, 2022; Smartico.Ai, 2023). The process of adding games or game-like elements to encourage participation has become an effective way for teachers to engage their students. For STEAM (Science, Technology, Engineering, Art, And Mathematics) education, this type of pedagogy is uniquely suited to create an environment that subverts the traditional classroom setting, transforming it into a space that encourages interaction and exploration (Asigigan & Samur, 2021). The classroom becomes more interactive and the students get many new experiences in their project sciences and art.

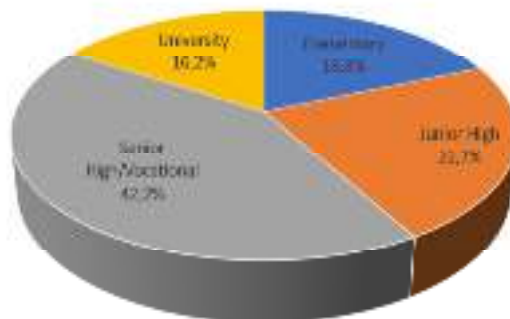


Figure 1: Implementation of STEM Learning Based on Participant Education Unit (Farwati et al., 2021)

Teungku Chik Pantekulu Darussalam Secondary School is part of Islamic Boarding School of Teungku Chik Pantekulu (Mts Teungku Chik Pante Kulu) established in 2020 (Saputra, 2021). During the education process, the school implemented a common curriculum with integration of some courses that related to science and technology. The regular time for study is taking place from Monday to Friday from 07.30 AM to 04.10 PM with a combination of Islamics and common school subjects. On Saturday, they have STEAM Classes. The classes are compulsory and classified for students based on their interests, skills, and test results. The students will be tested from class one (first year) and in the next year, the students are allowed to take another test if they want another STEAM class or they want to change it.

The implementation of learning STEAM Classes at the MTs Teungku Chik Pantekulu is still finding many problems and spaces for enhancement. There are many ways to measure the level of success of implementing a system or technology within the scope of our activities. This measurement can also be assessed from several assessment points of view which will provide an overview of which important points are strengths and important points are weaknesses (Saputra, 2022). This research is trying to explore the potential development and escalation of the process using one of the measurement methods by analyzing using SWOT analysis method. A SWOT analysis for schools can be described as a tool that provides prompts to the school directors, management teachers, and staff involved in the study of what is practical and less effective in the schools' systems and procedures that are often used in preparation for a plan of some form (that could be an audit, assessments, and quality checks (Mike Morrison, 2018).

Therefore, based on the introduction above, this research aims to take an approach of SWOT analysis to measure the level of effectiveness of using gamification in STEAM learning and education through the use of Scratch (Yamamori, 2019; Oh et al., 2013). This research is also expected to be able to describe recommendations for other applications or digital media used so that it can be a reference for other schools for implementation. This research itself is divided into several parts and the first part contains an introduction that tells the background of this research. In the second part, the discussion will be about the research methodology used in taking data samples and the process of extracting information. The third part tells about the results and discussion of this study and the last part contains the conclusions of the research. Ultimately, this research objective would aim to



provide valuable insights into the most successful approaches to incorporating gamification into the STEAM curriculum to improve student outcomes.

2. METHODS

This research utilizes a quantitative and qualitative research methodology approach, which is considered the best way to get maximum results and observe many potential issues related to this research. The first phase begins with the identification process to clearly state what you want to achieve with this study, such as identifying strengths, weaknesses, opportunities, and threats related to STEM subjects. The next step, this research determine who is involved or affected by the use of gamification in STEAM education, including students, teachers, parents, administrators, etc. After that, the research reviews existing studies and articles on gamification in education, focusing specifically on its impact on STEAM subject areas before identifying and producing survey questions. Then, successively, this research analyzes the results of the survey aimed at respondents and adds SWOT analysis to it before analyzing the final results which are under the research limitations. Completely, the flowchart of the research method can be shown in Figure 2.



Figure 2: Research Methodology

3. RESULTS & DISCUSSION

A SWOT analysis generally requires decision-makers to first specify the objective they hope to achieve for the business, organization, initiative, or individual (Bigelow et al., 2023). From there, the decision-makers list the strengths and weaknesses as well as opportunities and threats. SWOT analysis usually is used for a company to examine four elements which is the first one is internal attributes and resources that support a successful outcome, such as a diverse product line, loyal customers, or strong customer service, this is called strength. The second one is called weakness described as internal factors and resources that make success more difficult to attain, such as a weak brand, excessive debt, or inadequate staffing or training. There are two other examinations related to external factors that the organization can capitalize on or take advantage of, such as favorable export tariffs, tax incentives, or new enabling technologies, which are described as opportunities. Later on, the last one called threat, is described as external factors that could jeopardize the entity's success, such as increasing competition, weakening demand, or an uncertain supply chain. The main important thing related to the area of education is the value of solving localized issues and challenges.

In this research, the four elements of SWOT analysis are defined as the main objectives of the research. The objective of this research is to assess the strengths, weaknesses, opportunities, and threats associated with implementing gamification strategies in STEAM education. By conducting a SWOT analysis, the study aims to identify the internal strengths and weaknesses of using gamification in STEAM subjects, as well as external opportunities and threats that may impact its effectiveness. investigate the relationship between gamification



techniques and student motivation and engagement levels in STEAM subjects. The goal would be to determine if there is a positive correlation between the implementation of gamification methods and increased interest, enthusiasm, and participation among students in STEAM courses. Additionally, the research could explore whether certain types of gamification strategies are more effective than others at promoting student motivation and engagement in STEAM fields.

Students of MTs Teungku Chik Pantekulu are directly affected by the implementation of gamification strategies in STEAM classes, so they have an important perspective to share on the effectiveness of these methods. The process of implementation of gamification in this research is using Scratch. Scratch is the world's largest coding community for children and a coding language with a simple visual interface that allows young people to create digital stories, games, and animations (Scratch, 2024). Scratch is designed, developed, and moderated by the Scratch Foundation, a nonprofit organization. Scratch promotes computational thinking and problem-solving skills, creative teaching and learning, self-expression and collaboration, and equity in computing (Yamamori, 2019). As mentioned in the introduction section, students have to learn every Saturday in the specified class. In the Scratch class or section, they will be taught how to create simple computer programs that use the STEAM approach. The case that was created as a project in this section uses using classic pong game which is modified with some instructions (Figure 3). Teachers are responsible for designing and delivering STEAM curriculum, so they must understand the pros and cons of integrating gamification into their lessons. Both groups have a vested interest in ensuring that gamification improves student performance in STEAM subjects, so it is essential to involve them in the research process to ensure that the findings are relevant and useful to all parties involved.



Figure 3: Classic Pong Game modified for STEAM Class. Can be tested at <https://scratch.mit.edu/projects/964647381>

Gamification in learning STEAM subjects using game-based platforms like Scratch offers both advantages and disadvantages. Scratch, as mentioned before is a visual programming language, that can make learning STEAM concepts more engaging and interactive for students. By gamifying the learning process through Scratch, students can develop computational thinking skills, creativity, and problem-solving abilities in a fun and hands-on way. They start to think about what to do at the beginning of creating a pong game, discuss the concept, and finalize the idea. During the class, to reduce the gaps between students, the teacher is making a group for final project. These stages help them to talk and discuss more about the idea of the game. These approaches can enhance their motivation and interest in STEAM subjects, leading to improved learning outcomes.



In a classic Pong game created using Scratch, the STEAM elements are evident in various aspects of the game design and development process. The game involves a ball and a paddle, where the paddle hits the ball to bounce it off a wall before it returns towards the paddle. This simple yet engaging gameplay incorporates elements of physics (Science) in terms of ball movement and collision dynamics. The interactive nature of the game encourages problem-solving and critical thinking (Technology) as players strategize to hit the ball effectively. The visual and creative aspects of designing the game, such as choosing backgrounds, colors, and sprites, involve elements of art and design (Arts). Additionally, the coding and programming required to create the game emphasize mathematical concepts (Mathematics) like coordinates, angles, and speed calculations.

In the modification stages, the game offers more about critical thinking. The game added stage 2 where the condition describes as the ball successfully hit the paddle 10 times, the player will move to level 2. In level 2, the difficulties were made more difficult in moving the ball. The ball will move 3 times faster than level 1. Another modification made is a condition that informed students about losing or winning the game. The condition was made during the winning or losing condition is the user will get a notification and a short music about losing or winning. However, there are also drawbacks to using gamification with Scratch in STEAM education. One potential disadvantage is the risk of students focusing more on the game-like elements rather than the actual educational content. The teachers are feeling this condition. This may lead to a superficial understanding of concepts or a lack of depth in learning. Additionally, designing effective gamified activities using Scratch requires time and expertise from teachers, which can be a challenge for teachers who are not familiar with the platform or game design principles at MTs Teungku Chik Pantekulu. Despite these challenges, the school director hopes that this curriculum can be implemented thoughtfully and that gamification with Scratch can be a powerful tool for enhancing STEAM education by making learning more interactive and enjoyable for students.

The next phase of the research is formulating the right question for identification SWOT Analysis. There are different aspects with several research processes using SWOT analysis which takes research objects at MTs Teungku Chik Pantekulu. This analysis is devoted to finding the strengths, weaknesses, opportunities, and threads of the gamification in STEAM class implementation. The questions along with the percentage of the results of the answers submitted in this analysis. The survey questions are separated into two types of stakeholders as mentioned above which are students and teachers. The number of respondents who took part in this research involved all students and teachers consisting of 15 teachers and 25 students. The answers to survey results are identified with Yes (pointed with 80-100), Uncertain (pointed with 40-79), and No (pointed with 0-39). The percentage value is calculated using the formula below,

$$p = f/n \times 100 \quad \dots\dots\dots (1)$$

p : Percentage

f : Frequency of each questionnaire answer

n : Number of respondents

The results of the survey questions are figured in Table 1.

Table 1. SWOT Analysis on Gamification using Scratch for STEAM Lesson in Students Perceptions

No.	SWOT Analysis	Questions	Percentages
1.	Strengths	The classic Pong game in Scratch is a helpful tool for learning STEAM concepts	80%
		Playing the classic Pong game improved your understanding of physics principles in motion and collision.	86%
		The classic Pong game has enhanced your problem-solving skills in a STEAM context.	78%



2.	Weakness	Have you encountered any challenges or limitations while playing the classic Pong game in Scratch related to learning STEAM subjects?	60%
		The classic Pong game that you find confusing or difficult to grasp in terms of STEAM concepts.	60%
		The classic Pong game adequately represents all the relevant STEAM elements it aims to teach.	60%
3.	Opportunities	The classic Pong game could be further developed to better support learning in STEAM subjects	80%
		Can you suggest any additional features or modifications to the classic Pong game that would enhance its educational value in STEAM education?	75%
		Playing the classic Pong game could be integrated into other STEAM topics for a more comprehensive learning experience	75%
4.	Threats	Are there any risks associated with relying too heavily on the classic Pong game as a learning tool for STEAM subjects?	75%
		Do you see any potential drawbacks or negative consequences of using gamified elements like the classic Pong game in Scratch for teaching STEAM concepts?	75%
		How concerned are you about the possibility of students becoming overly focused on gaming aspects rather than educational outcomes when using the classic Pong game in a STEAM context?	84%

From Table 1, you can see several important points identified through the 4 main SWOT analysis points. The respondents who were students gave answers that tended to be the same. This is shown by their perception value towards the classic Pong Game which tends to be on average >70% agree. This also proves the initial assumption of this research that students tend to prefer and understand learning more easily if they find unique and new learning media. They state the high point in question about how playing the classic Pong game improved their understanding of physics principles in motion and collision. For the survey questions related to teachers perceptions can be figured in Tabel 2,

Table 2. SWOT Analysis on Gamification using Scratch for STEAM Lesson in Teachers Perceptions

No.	SWOT Analysis	Questions	Percentages
1.	Strengths	You perceive the classic Pong game in Scratch as an effective tool for teaching STEAM concepts to students	85%
		You believe the classic Pong game enhances student engagement and understanding of STEAM principles compared to traditional teaching methods	85%
		Have you observed any improvements in student performance or motivation when using the classic Pong game as a gamified learning tool in STEAM subjects?	85%
2.	Weakness	You encounter challenges when integrating the classic Pong game into your STEAM curriculum for educational purposes	90%
		There are any limitations or drawbacks associated with using the classic Pong game that hinder student learning or comprehension of STEAM concepts	70%
		You find it difficult to align the educational objectives of teaching STEAM subjects with the gaming elements present in the classic Pong game	90%
3.	Opportunities	You envision expanding or modifying the classic Pong game to better support student learning and engagement across various STEAM topics	85%



4.	Threats	You can suggest any new features or enhancements that could be incorporated into the classic Pong game to improve its effectiveness as a teaching tool in STEAM education	80%
		You believe in some way that gamified elements like the classic Pong game could be integrated into other areas of your STEAM curriculum to enhance student outcomes	85%
		You have potential risks or challenges foresee in using gamified elements such as the classic Pong game extensively in teaching STEAM subjects	90
4.	Threats	There are some concerns about students becoming overly focused on gaming aspects rather than mastering essential STEAM concepts when using the classic Pong game in your lessons	85
		Do you worry about maintaining a balance between educational content delivery and gaming elements when incorporating the classic Pong game into your STEAM teaching practices?	85

From Table 2, we can identify that You believe the classic Pong game enhances student engagement and understanding of STEAM principles compared to traditional teaching methods is a strong point in the SWOT analysis. The classic Pong game, when used as a gamified learning tool, can make STEAM subjects more interactive and enjoyable for students. The survey gives this point of the question the highest number of positive aspects. On the negative aspects involving weaknesses and threats, the survey in this study showed high scores, especially in the points of developing learning objects and challenges in developing new gamification materials. This can happen because to prepare new gamification material, teachers need time and the process takes quite a long time. From the results of direct interviews, to modify the pong classing game being tested, one of the teachers took more than one day to complete it. Finally, this research identifies the final purposes of SWOT analysis in enhancing students' performance in STEAM Courses using the gamification approach in the infographic in Figure 4.

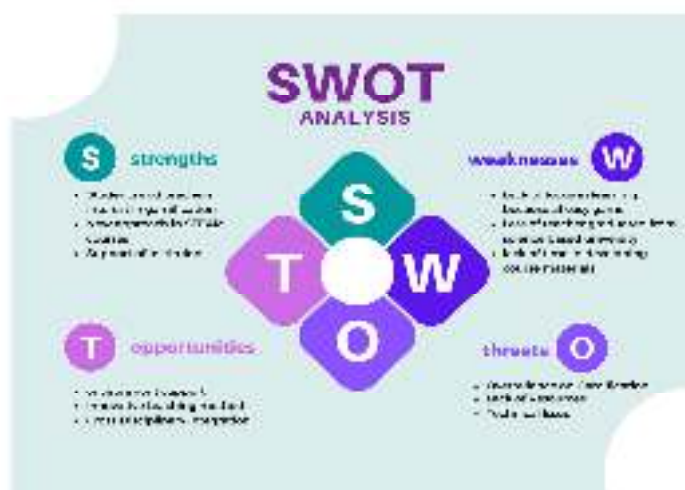


Figure 4: Infographic of SWOT Analysis in Enhancing Students Performance of STEAM Courses using Gamification Approach

Some key points can be highlighted for future development courses from the infographic above. Innovative Teaching Methods can be the opportunity to leverage gamification, such as the classic Pong game in



Scratch, which presents a chance for educators to adopt innovative teaching methods that cater to diverse learning styles. By incorporating gamified elements into STEAM education, teachers can create a more dynamic and interactive learning environment that resonates with students, potentially leading to increased academic performance and engagement. Cross-disciplinary integration can be the use of gamification like the classic Pong game offers an opportunity to seamlessly integrate various STEAM disciplines. Educators can design gamified activities that bridge concepts from science, technology, engineering, arts, and mathematics, fostering a holistic understanding of interconnected subjects. This integration can enhance students' ability to apply knowledge across different domains and develop a well-rounded skill set. Personalized Learning Experiences in gamification provide an opportunity for personalized learning experiences tailored to individual student needs and preferences. Through the classic Pong game and similar gamified approaches, educators can adapt content delivery, challenges, and feedback to suit each student's pace and learning style. This personalized approach can optimize student engagement, motivation, and comprehension of STEAM concepts, ultimately enhancing overall performance in these subjects.

Besides the good opportunities mentioned above, several threats should be a concern for school management or directors. Three potential threats in the SWOT analysis for Student Performance in STEAM through Gamification are projected in an infographic. Overreliance on Gamification, if gamification becomes overly reliant on gaming elements rather than educational objectives, it could lead to a lack of focus on the core STEAM principles, potentially hindering student learning and performance. The second one is lack of resources, If resources such as time, money, and personnel are not adequately allocated to support the gamification of STEAM education, it could lead to a lack of effective implementation, potentially affecting student performance. The last one is technical issues, which can arise with the gamification tools or platforms used in STEAM education, it could lead to disruptions in the learning process, potentially affecting student performance.

4. CONCLUSION

In conclusion, the research highlights the potential of gamified approaches, such as the classic Pong game in Scratch, to positively impact student engagement, understanding of STEAM principles, and problem-solving skills. By leveraging innovative teaching methods and integrating gamification into STEAM education, educators have the opportunity to create personalized learning experiences that cater to diverse student needs and foster cross-disciplinary integration. However, it is essential to be mindful of potential threats such as overreliance on gamification, resource limitations, and technical issues that could impact the effectiveness of these approaches. Moving forward, further exploration and careful implementation of gamified strategies in STEAM education can lead to enhanced student performance and a more dynamic learning environment that prepares students for success in an increasingly complex and interconnected world.

Future research could delve deeper into the long-term effects of gamified learning approaches on student outcomes, retention of knowledge, and transferability of skills beyond the classroom. Exploring the sustainability and scalability of gamification in STEAM education, as well as investigating the impact on students' intrinsic motivation and self-directed learning abilities, could provide valuable insights for educators and policymakers. Additionally, research focusing on the development of more advanced gamification tools and platforms tailored to specific STEAM disciplines could further optimize the effectiveness of gamified learning experiences. Furthermore, collaboration among educators, researchers, and developers is essential to drive innovation in gamification tools and ensure their alignment with educational objectives. By staying informed about best practices and emerging trends in gamified learning, educators can empower students to thrive in STEAM disciplines and cultivate a lifelong passion for learning.

5. ACKNOWLEDGMENTS

Acknowledgment of Onedigit Technology Research and Development is paramount for their invaluable support in facilitating and advancing the research. Their dedication to innovation and commitment to educational



excellence have been instrumental in shaping the trajectory of this study. The expertise, resources, and collaborative spirit provided have significantly contributed to the exploration of gamified learning approaches. Their partnership has been pivotal in driving forward this research endeavor and fostering a culture of continuous improvement and advancement in educational practices.

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