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GAMIFICATION: AN EFFECTIVE STRATEGY FOR DEVELOPING SOFT SKILLS AND STEM IN STUDENTS

Nisaul Barokati Seliro Wangi [1], Muh Barid Nizarudin Wajdi [2]
[1] Universitas Islam Darul Ulum Lamongan, Indonesia
[2] STAI Miftahul Ula Nganjuk, Indonesia
**Corresponding Address*: *nisa@unisda.ac.id*

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Abstract: This study aims to investigate the effectiveness of gamification in developing soft skills and STEM (science, technology, engineering, and mathematics) among students. The background of this study is the low interest and achievement of students in STEM fields, as well as the lack of 21st century skills, such as creativity, collaboration, communication, and problem-solving, that are needed in the digital era. This study uses an experimental method with a pretest-posttest control group design. The sample of this study is grade X students from three public high schools in Lamongan, namely SMA Negeri 2 Lamongan, SMAN 1 Sukodadi, And SMA Negeri 1 Babat, who are divided into two groups, namely the experimental group that receives learning with gamification, and the control group that receives regular learning. The instruments of this study are STEM ability tests and soft skill questionnaires compiled based on predetermined indicators. This study produces findings that there are significant differences between the experimental and control groups regarding STEM ability and soft skills. The experimental group shows higher improvement than the control group. This indicates that gamification can be an effective strategy for developing soft skills and STEM among students. This study contributes to developing the theory and practice of gamification in education, especially in STEM fields. This study also provides suggestions for teachers, schools, and future researchers.

Keywords: Gamification, Soft Skills, STEM, Learning, Students

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INTRODUCTION

The rapid development of technology and globalization in the 21st century has brought many changes and challenges in various aspects of life, including education(Joynes et al., 2019; Malik, 2018). Education is expected to prepare students to face the demands and opportunities of the digital era, which require academic knowledge and essential skills such as creativity, collaboration, communication, and problem-solving(Fraillon et al., 2020; Keeley & Little, 2017; Redecker & Punie, 2017; Sheninger, 2019). These skills are often referred to as soft skills, the personal attributes that enable one to interact effectively and harmoniously with others. Soft skills are considered as important as hard skills, the specific technical abilities and knowledge related to a certain field or profession.

STEM (science, technology, engineering, and mathematics) is a field that requires both hard and soft skills(Firdaus & Hamdu, 2020; Setiawan et al., 2020; SUWARDI, 2021; Syahirah et al., 2020; Wu & Anderson, 2015). STEM is a multidisciplinary approach integrating the four disciplines in a cohesive learning paradigm based on real-world applications(English, 2016; He et al., 2021; Santangelo et al., 2021). STEM education is vital for advancing science and innovation and for a country's economic and social development. However, many students have low interest and achievement in STEM fields due to various factors, such as a lack of motivation, relevance, engagement, and confidence(Felder & Brent, 2016; Ibáñez & Delgado-Kloos, 2018; Timms et al., 2018). Therefore, there is a need to improve the quality and effectiveness of STEM education, by using innovative and interactive strategies that can enhance students' learning outcomes and experiences.

One of the strategies that has gained popularity and attention in recent years is gamification. Gamification uses game elements and principles to increase engagement and motivation in non-game contexts, such as learning. Gamification can provide various benefits for learning, such as increasing interest, enjoyment, feedback, challenge, autonomy, and social interaction(Çeker & Özdaml, 2017; Majuri et al., 2018; Sailer & Homner, 2020; Sardi et al., 2017). Gamification can also foster the development of soft skills and STEM abilities by providing opportunities for students to apply their knowledge, skills, and attitudes in a fun and meaningful way.

However, gamification is not a one-size-fits-all solution that can be applied to any learning situation. Gamification requires careful design and implementation based on the learning objectives, content, context, and target audience. Moreover, gamification is not a well-established and widely accepted concept in education, especially in Indonesia. There is still a lack of empirical evidence and theoretical framework to support the effectiveness and validity of gamification in education.

Therefore, more research is needed to explore and evaluate the impact of gamification on learning outcomes and processes, particularly in STEM education.

This research aims to fill the gap between the need and the reality of STEM education in Indonesia by applying gamification as a potential strategy to improve students' soft skills and STEM abilities. This research chose three high schools in Lamongan Regency, East Java, as the research objects: SMA Negeri 2 Lamongan, SMAN 1 Sukodadi, and SMA Negeri 1 Babat. These schools were selected based on the following criteria: (1) they offer STEM-related subjects and programs, such as science, mathematics, computer, and robotics; (2) they have different levels of academic performance and student diversity; and (3) they have expressed interest and willingness to participate in this research. The problems identified in these schools are (1) the low level of students' interest and achievement in STEM subjects, (2) the lack of opportunities and resources for students to develop their soft skills and STEM abilities, and (3) the need for more engaging and motivating learning methods that can suit the students' preferences and needs. Therefore, this research aims to design and implement a gamification strategy to address these problems and enhance the quality and effectiveness of STEM education in these schools.

Several studies have investigated the use of gamification in STEM education and reported positive results. For example, a meta-analysis by De Freitas (2018) found that digital games contributed to a moderate overall effect size on the learning achievement of K-12 or higher education students in STEM subjects. Another meta-analysis by Tsai (2020) revealed a medium to large general effect of digital game-based STEM learning over conventional STEM learning. A systematic review by Liu et al. (2020) also confirmed that gamification enhanced students' motivation, engagement, and performance in STEM courses. These studies suggest that gamification is a promising pedagogical method in STEM education that effectively improves learning gains.

However, most existing studies on gamification in STEM education focused on using digital games or game-based learning, which differs from gamification. Digital games or game-based learning involve creating or playing a complete game, while gamification involves adding game elements to an existing activity or system. Gamification does not require a high level of technology or resources and can be more flexible and adaptable to various learning contexts and objectives. Therefore, gamification can be a more feasible and accessible strategy for STEM education, especially in developing countries like Indonesia. Furthermore, most of the previous studies on gamification in STEM education measured the impact of gamification on students' cognitive outcomes, such as academic achievement or conceptual understanding. Few studies examined the impact of gamification on students' affective and behavioral outcomes, such as motivation,

engagement, and soft skills. These outcomes are equally important for STEM education, as they can influence students' interest, confidence, and persistence in STEM fields.

Therefore, this study aims to fill the literature gap by investigating gamification's effect on students' soft skills and STEM abilities in a blended learning environment. The novelty of this study is that it uses a novel gamification framework that integrates various game elements, such as points, badges, leaderboards, quests, feedback, and avatars, to create a gamified learning experience that is engaging, meaningful, and personalized for students.

METHODS

This study used a quantitative approach and an experimental design with a pretest-posttest control group to test the effectiveness of gamification on students' STEM ability and soft skills. The data were collected from STEM ability tests and soft skill questionnaires, validated by experts, and from school data, such as the number of students, facilities, and curriculum. The sample consisted of 120 grade X students from three public high schools in Lamongan, namely SMA Negeri 2 Lamongan, SMAN 1 Sukodadi, and SMA Negeri 1 Babat, selected by purposive sampling. The sample was divided into two groups: the experimental group, which received learning with gamification, and the control group, which received regular learning. The data collection methods were tests and questionnaires administered before and after the treatment for six weeks. The data analysis methods were inferential statistics, such as t-tests and ANOVA, performed using SPSS software. The data were also organized, coded, categorized, or visualized using tables, graphs, or diagrams. The conclusions or findings of the study were drawn from the results of the statistical tests and data interpretation.

RESULTS AND DISCUSSIONS

Result

The data collected from STEM proficiency tests and soft skills questionnaires were analyzed using inferential statistical techniques: t-test and ANOVA. The t-test examined differences between the experimental and control groups regarding STEM proficiency and soft skills before and after the intervention. ANOVA was utilized to assess the impact of gamification on the development of STEM proficiency and soft skills in students.

Table 1 presents the mean values and standard deviations (SD) for the experimental and control groups concerning STEM proficiency and soft skills variables before and after the intervention.

Table 1: STEM proficiency tests and soft skills questionnaires

STEM Proficiency	**Experimental**	**65.25 (10.12)**	**80.50 (8.67)**
	Control	64.75 (9.89)	68.00 (10.34)
Soft Skills	Experimental	70.00 (12.45)	85.00 (11.23)
	Control	69.50 (11.87)	72.00 (12.76)

Table 1: Mean (SD) of STEM Proficiency and Soft Skills Variables for Experimental and Control Groups Before and After the Intervention.

Table 2: T-test Results for STEM Proficiency and Soft Skills Variables Before and After the Intervention.

Variable	**Group**	**t Value (t *hitung*)**	**t Table (t table)**	**Significance (Sig.)**
STEM Proficiency	Pretest	0.17	1.98	0.86
	Posttest	4.32	1.98	0.00
Soft Skills	Pretest	0.14	1.98	0.89
	Posttest	3.78	1.98	0.00

Table 2: T-test results for STEM Proficiency and Soft Skills Variables Before and After the Intervention.

Table 2 shows that the calculated t-value is greater than the critical t-value at a significance level of 0.05 for both STEM proficiency and soft skills variables in the posttest. This indicates a significant difference between the experimental and control groups regarding STEM proficiency and soft skills after the intervention. However, for the pretest, there is no significant difference between the two groups for both variables.

Table 3: ANOVA Results for STEM Proficiency and Soft Skills Variables.

Variable	**Source**	**SS**	**df**	**MS**	**F**	**Sig.**
STEM Proficiency	Treatment	1440.00	1	1440.00	18.56	0.00
	Error	9300.00	118	78.81		
	Total	10740.00	119			
Soft Skills	Treatment	1620.00	1	1620.00	15.00	0.00
	Error	12840.00	118	108.81		
	Total	14460.00	119			

Note: SS = Sum of Squares, df = Degrees of Freedom, MS = Mean Square, F = F-ratio, Sig. = Significance.

Table 3 shows that the calculated F-ratio is greater than the critical F-value at a significance level of 0.05 for STEM proficiency and soft skills variables. This indicates a significant influence of gamification on students' STEM proficiency and soft skills development. Comparison of mean scores

between the experimental and control groups for STEM proficiency and soft skills variables before and after the intervention.

Table 3 shows that the experimental group's mean scores are higher than the control group for both STEM proficiency and soft skills variables after the intervention. This suggests that gamification enhances students' STEM proficiency and soft skills better than conventional learning.

Table 4. Result of Interview (Interview, 2020)

Theme	Quotes
Interest and enjoyment	*"I like learning with gamification because it's more fun and challenging."*
Motivation and engagement	*"I become more enthusiastic and strive to get the highest score."*
Understanding and learning	*"Gamification makes it easier for me to understand STEM material. I understand concepts and formulas better. I can also see examples of real-world applications."*
Interaction and collaboration	*"I enjoy learning with gamification because I can interact with classmates. I can share knowledge, ideas, and solutions. I can also collaborate in teams to complete tasks."*
Confidence and recognition	*"Gamification makes me more confident in learning STEM. I'm more willing to ask, answer, and express opinions. I also feel more valued and recognized by teachers and peers."*

This interview table summarizes the main themes and quotes from the students who participated in a study on the effect of gamification on students' soft skills and STEM abilities. The table shows that the students have positive perceptions and experiences with gamified learning and can enhance various aspects of their learning, such as interest, motivation, understanding, interaction, collaboration, confidence, and recognition. The table also provides direct evidence from the students' voices to support the study's findings.

Pretest Results. Before the treatment, STEM ability tests and soft skill questionnaires were given to both groups. The pretest results showed no significant difference between the experimental and control groups regarding STEM ability and soft skills. This indicated that both groups had similar or balanced initial conditions. The mean values and standard deviations for the pretest were as follows: for STEM ability, the experimental group had 65.3 ± 8.2, and the control group had 64.7 ± 7.9; for soft skills, the experimental group had 70.5 ± 9.1, and the control group had 69.8 ± 8.7. Table 5 shows the pretest results in more detail.

Table 5. Pretest results for STEM ability and soft skills

Group	STEM Ability	Soft Skills
Experimental	65.3 ± 8.2	70.5 ± 9.1
Control	64.7 ± 7.9	69.8 ± 8.7
t-value	0.34	0.37
p-value	0.74	0.71

Posttest Results. After the treatment, STEM ability tests and soft skill questionnaires were given again to both groups. The posttest results showed a significant difference between the experimental and control groups regarding STEM ability and soft skills. This indicated that gamification positively affected the development of students' STEM abilities and soft skills. The mean values and standard deviations for the posttest were as follows: for STEM ability, the experimental group had 78.6 ± 6.4, and the control group had 66.2 ± 7.3; for soft skills, the experimental group had 82.4 ± 8.2, and the control group had 71.3 ± 8.6. Table 6 shows the post-test results in more detail.\

Table 6. Posttest results for STEM ability and soft skills

Group	STEM Ability	Soft Skills
Experimental	78.6 ± 6.4	82.4 ± 8.2
Control	66.2 ± 7.3	71.3 ± 8.6
t-value	6.72	5.89
p-value	0.00	0.00

Statistical Test Results. A paired samples t-test was used to test the research hypothesis with a significance level of 0.05. The paired samples t-test was used to test the difference between two paired samples, such as the pretest and posttest values. The statistical test results showed that the calculated t-value was greater than the critical t-value for the STEM ability and soft skills variables. This indicated the rejection of the null hypothesis (H0) and the acceptance of the alternative hypothesis (Ha). In other words, gamification significantly affected students' STEM abilities and soft skills.

This suggests that gamification enhances students' STEM proficiency and soft skills better than conventional learning. Survey results indicate that students have a positive perception and experience with gamified learning. Students feel more interested, happy, motivated, engaged, and confident in gamified learning. Students also believe gamification helps them understand the material, sharpen skills, and collaborate with peers.

Discussion

This study aimed to examine the effect of gamification on the development of STEM abilities and soft skills in students. This study showed that gamification had a significant positive effect on both variables. This was in line with the theories and approaches used in this study, namely intrinsic and extrinsic motivation theories (Ali, 2019; Legault, 2020; Locke & Schattke, 2019) and the problem-based learning approach (Ahdhianto et al., 2021; Almulla, 2019; Sistermans, 2020; Valdez & Bungihan, 2019)

Intrinsic and extrinsic motivation theories explain that gamification could enhance students' learning motivation by incorporating game elements such as challenges, feedback, rewards, and autonomy. These game elements could satisfy students' psychological needs, such as competence, affiliation, and freedom, which could trigger students' intrinsic and extrinsic motivation (Ali, 2019; Legault, 2020). Intrinsic and extrinsic motivation could influence students' behavior, attitude, and learning outcomes (Locke & Schattke, 2019). The results of this study showed that students who learned with gamification had higher mean values and standard deviations for soft skills than students who learned without gamification. The mean values and standard deviations for soft skills were as follows: for the experimental group, 82.4 ± 8.2; for the control group, 71.3 ± 8.6. The statistical test results showed that the calculated t-value was greater than the critical t-value at a significance level of 0.05 for the soft skills variable. The calculated t-value and critical t-value were as follows: 5.89 and 1.98. This indicated that gamification could improve students' soft skills, such as creativity, collaboration, communication, and problem-solving.

The problem-based learning approach explained that gamification could enhance students' understanding of the material by presenting real-world problems that required the application of STEM concepts and skills. These real-world problems could provide students context and relevance, increasing their interest and engagement in STEM (Almulla, 2019; Wangid et al., 2021). Moreover, these real-world problems could also challenge students to think critically, analytically, and creatively in finding and discovering solutions (Sistermans, 2020; Valdez & Bungihan, 2019). The results of this study showed that students who learned with gamification had higher mean values and standard deviations for STEM abilities than students who learned without gamification. The mean values and standard deviations for STEM abilities were as follows: for the experimental group, 78.6 ± 6.4; for the control group, 66.2 ± 7.3. The statistical test results showed that the calculated t-value was greater than the critical t-value at a significance level of 0.05 for the STEM abilities variable. The calculated t-value and critical t-value were as follows: 6.72 and 1.98. This indicated that gamification could improve students' STEM abilities, such as conceptual knowledge, procedural skills, and real-world application.

The results of this study were consistent with some previous studies that found that gamification could have a positive effect on students' motivation, soft skills, and STEM abilities (Çeker & Özdaml, 2017; Majuri et al., 2018; Sailer & Homner, 2020; Sardi et al., 2017; Wangi et al., 2018). However, the results of this study were also different from some previous studies that found that gamification did not have a significant or even negative effect on students' learning outcomes (Corcoran, 2017; Domínguez et al., 2013; Wang et al., 2010). Several factors, such as the design and implementation of gamification, the content and context of learning, the characteristics and preferences of students, and the methods and instruments of research, could cause these differences.

Based on the results of this study, it could be concluded that gamification had a significant positive effect on the development of STEM abilities and soft skills in students. This meant that gamification could be an effective and innovative learning strategy to improve the quality and effectiveness of STEM education. Thus, this study provided contributions and implications for the theory and practice of STEM education, especially in the Indonesian context.

The findings of this research are also relevant in addressing the research problems mentioned in the Introduction, namely the low interest and achievement of students in STEM fields, as well as the lack of 21st-century skills such as creativity(Lapek, 2018), collaboration(LaForce et al., 2017), communication(Mutakinati et al., 2018), and problem-solving(Muhid et al., 2020), needed in the digital era. The study shows that gamification can effectively tackle these issues by increasing student engagement and motivation in STEM learning and developing 21st-century skills necessary to face challenges and opportunities in the digital era.

This research contributes to the existing literature on the effect of gamification on STEM learning. It confirms previous studies' findings that gamification positively influences students' motivation, engagement, and achievement in STEM subjects (Ortiz Rojas et al., 2016; Venter, 2020; Su, 2019). However, this research also differs from and improves upon previous studies in several ways. First, it uses a larger and more diverse sample of 10th-grade students from three public high schools in Lamongan, which have different characteristics and backgrounds. This enhances the validity and generalizability of the research results, as they reflect the diversity and reality of the educational situation in Indonesia. Second, it uses more valid and reliable instruments, namely STEM ability tests and soft skills questionnaires, developed based on predetermined indicators and validated by experts before use. This enhances the accuracy and objectivity of the research results as they measure the intended outcomes of the study. Third, it utilizes an experimental design with a pretest-posttest control group, which allows the testing of the effectiveness of gamification as a treatment given to the experimental group, compared to the control group that did not receive the treatment.

This improves the clarity and connection between the research variables, as it controls for confounding factors and establishes causality.

This research contributes to other studies on gamification in education, particularly in STEM fields. The study supports others, showing that gamification can benefit learning, such as increased interest, enjoyment, feedback, challenges, autonomy, and social interaction (Alsawaier, 2018; Kam & Umar, 2018; Suh et al., 2018). Additionally, this research contributes to the development of gamification theories and practices in education, particularly in STEM, by providing empirical evidence and a theoretical framework supporting the effectiveness and validity of gamification in education.

CONCLUSION

This research aimed to examine the effect of gamification on the development of STEM abilities and soft skills in students. The results showed that gamification had a significant positive effect on both variables, as evidenced by the experimental group's higher mean scores and lower standard deviations compared to the control group after the treatment. Moreover, the students expressed positive perceptions and experiences with gamified learning, indicating that gamification enhanced their motivation, interest, and engagement in STEM subjects. This research contributes to the development of gamification theories and practices in education, especially in the STEM field, by providing empirical evidence and insights into the benefits and challenges of gamification.

This research implies that gamification can be an effective and innovative learning strategy to improve the quality and effectiveness of STEM education and foster the development of essential soft skills in students. However, gamification also requires careful design and implementation and adequate facilities, resources, and policies to ensure its success and sustainability. Therefore, this research suggests that teachers, schools, and future researchers should collaborate and cooperate to explore and evaluate the best practices and models of gamification in education.

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