JPPIPA 10(12) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

The 5E Learning Cycle: A Pathway to Better Science Problem-Solving Skills through Classcraft Gamification

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Received: October 4, 2024
Revised: November 27, 2024
Accepted: December 25, 2024
Published: December 31, 2024

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DOI: 10.29303/jppipa.v10i12.9344

Abstract: Problem-solving skills are essential for students to navigate both academic challenges and real-world situations effectively. However, many junior high school students struggle to develop these skills, particularly in science education. This study aims to explore the effects of gamification, using Classcraft, integrated into the 5E Learning Cycle model on the science problem-solving skills of seventh-grade students. Conducted as a quasi-experimental study with a non-equivalent control group pretest-posttest design, the research involved a cluster random sample of public junior high schools in Yogyakarta. A pretest-posttest problem-solving skills test was administered, with instruments validated using Pearson correlation and reliability measured through Cronbach's alpha. Data analysis employed independent sample t-tests and effect size to determine the impact of the intervention. The results demonstrate that Classcraft-assisted gamification within the 5E Learning Cycle significantly enhances students' problem-solving abilities. This suggests that integrating gamification into instructional models not only boosts engagement but also fosters critical thinking skills crucial for everyday decision-making and problem resolution, thereby equipping students with practical skills applicable to real-life situations.

Keywords: Classcraft; Gamification; Problem-Solving Skills; 5E Learning Cycle

Introduction

Problem-solving is widely recognized as a fundamental competency for the twenty-first century, particularly as individuals face increasing complexity in various domains of life (Funke et al., 2018). Those who possess strong problem-solving abilities tend to evolve into self-reliant, creative thinkers capable of navigating challenges independently (Thornhill-Miller et al., 2023). This capacity not only benefits the individual but also contributes to a society where people are equipped to address emerging issues with confidence and resourcefulness (Özreçberoğlu & Çağanağa, 2018). (Demirhan & Şahin, 2021) emphasized that problem-solving is a practical skill that can be nurtured through observation, imitation, and practice. The process requires learners to engage in deliberate steps, beginning with the observation of problem-solving approaches used by others and culminating in replicating those methods. (Kartini et al., 2021) further expanded on this by outlining a structured approach that involves understanding the problem, developing a plan, implementing it, and reflecting on the outcomes. Similarly, (Thornhill-Miller et al., 2023) identified key stages in problem-solving: comprehending the issue, formulating a plan of action, executing the plan, and evaluating the results. Given the importance of these skills, it is crucial for science education practitioners to implement instructional strategies that foster and enhance students' problem-solving capabilities (Astuti et al., 2020; Turiman et al., 2012).

Data indicate that approximately 68.97% of students exhibit low problem-solving skills, as evidenced by their performance on science problem-solving questions, where their scores remain below the minimum mastery criteria (Astuti et al., 2020; Taqiyyah et al., 2017). Previous research supports these findings, with (Demirhan & Şahin, 2021; Hastuti & Putri, 2022) reporting that 65% of students at a similar educational level struggle with complex problem-solving in

How to Cite:
Nurohman, S., Makmudah, M., & Tyas, R. A. (2024). The 5E Learning Cycle: A Pathway to Better Science Problem-Solving Skills through Classcraft Gamification. *Jurnal Penelitian Pendidikan IPA*, *10*(12), 11144–11151. https://doi.org/10.29303/jppipa.v10i12.9344

scientific contexts, highlighting the urgent need for enhanced instructional approaches. Several factors contribute to these low skills, including a lack of understanding of effective learning methods for students, an inability of students to recognize their own learning styles, and infrequent use of engaging and interactive learning media (Argaw et al., 2016; Sulistyowati et al., 2012). Additionally, research by (Mahanal et al., 2022; Purwaningsih et al., 2020) found that students who regularly utilize diverse and relevant learning media demonstrate significant improvements in their problem-solving skills. Therefore, it is crucial for educators to design more responsive and adaptive instructional strategies that cater to students' needs, thereby helping them to develop these essential skills more effectively (González-Pérez & Ramírez-Montoya, 2022).

Addressing this issue necessitates the implementation of a learning model specifically designed to enhance problem-solving skills (Shanta & Wells, 2022). According to (El-Sabagh, 2021; Keuning & van Geel, 2021), problem-solving abilities can be cultivated through a series of structured steps, including reading and thinking critically, planning academic skills, selecting appropriate resolution strategies, finding solutions, reviewing those solutions, and broadening one's understanding. In this context, it is essential to adopt a constructivist-based learning model that emphasizes cognitive conflict and promotes interactive experiences with the surrounding environment (Novita Sari et al., 2022). Such an approach not only fosters deeper engagement but also aligns with the intrinsic characteristics of science, which encourages inquiry and exploration (Wedyawati et al., 2017). By leveraging constructivist principles, educators can create a dynamic learning atmosphere that empowers students to take an active role in their learning, thereby effectively improving their problem-solving capabilities.

One learning model that aligns with the constructivist approach in science education is the 5E Learning Cycle model. This model enables students to actively construct their knowledge through a structured learning process comprising five phases: engagement, exploration, explanation, elaboration, and evaluation (Yuliana et al., 2020). Each stage of the learning cycle positions the teacher as a facilitator while students actively participate in their own learning journey.

The 5E Learning Cycle offers several advantages (Tse et al., 2022). Firstly, it promotes active learning, encouraging students to engage deeply with the content and facilitating meaningful connections with prior knowledge. Secondly, it supports differentiated instruction, allowing teachers to tailor activities to accommodate diverse learning styles and paces. Additionally, the model fosters collaboration among students, enhancing their communication and teamwork skills as they explore concepts together.

However, several limitations are associated with technology integration within the 5E Learning Cycle (Asrizal et al., 2022; Schallert et al., 2022). Firstly, access to technology and digital resources may not be consistent across all students, resulting in inequities in learning opportunities. This disparity can hinder the effectiveness of the learning cycle, as not all students may be able to engage with technology-enhanced activities. Teachers may struggle with effectively incorporating technology into each phase of the 5E model, particularly if they lack the necessary training or familiarity with educational technology tools (Turan, 2021). This gap can lead to underutilization of available resources, thereby diminishing the potential benefits of the learning cycle.

The complexity of managing various technological tools during the learning process can overwhelm both students and teachers, detracting from the focus on content mastery and problem-solving skills (Sormunen et al., 2020). In an era where technology is central to effective learning, it is essential to address these challenges to harness its full potential. Fortunately, integrating Classcraft Gamification may offer solutions to these limitations, providing an engaging and supportive framework that enhances both access to technology and the overall learning experience (Saleem et al., 2022; Shavab et al., 2021). Beside that, the use of information technology can stimulate the problem-solving skills.

Gamification refers to the incorporation of game elements into a learning context, making it accessible to both teachers and students. These platforms can either be pre-existing or specifically developed, such as Classcraft (Shavab et al., 2021). According to (Mambang et al., 2022), Classcraft is a game designed to help students cultivate positive behaviors, enhance knowledge acquisition, and improve communication and collaboration skills (Krishnan et al., 2021; Zhang et al., 2021). Classcraft offers numerous advantages, including engaging visuals and interactive features that captivate students' interest (Muliyati et al., 2024). Teachers have the flexibility to control the content and storyline settings within Classcraft, guiding students toward learning objectives while fostering teamwork and strengthening peer relationships (Muliyati et al., 2024; Zhang et al., 2021). This platform can be effectively utilized in both classroom settings and during after-school activities.

Given the potential of Classcraft to enhance the learning experience, it is essential to test the effectiveness of the 5E Learning Cycle model in a gamified format assisted by Classcraft for improving students' problem-solving skills. Therefore, this study aims to evaluate the impact of Classcraft-assisted gamification within the 5E Learning Cycle model on students' problem-solving abilities.

Method

This study is a quasi-experiment with a nonequivalent control group pretest-posttest design as shown in Table 1. A quasi-experiment with a nonequivalent control group pretest-posttest design involves two groups, an experimental group and a control group, where participants are not randomly assigned to these groups, which may result in initial differences between the groups (Furtak et al., 2012).

Table 1. Nonequivalent control group pretest-posttest design

	Pre-Test	Treatment	Post-Test
Experiment	O1	5E Learning Cycle	O2
Control	O3	Discovery Learning	O4

The research was carried out at a public junior high school in Sleman Regency, Special Region of Yogyakarta. The study population comprised all seventh-grade students, divided into four learning groups. A cluster random sampling technique was employed to select the sample, because the population was already organized into distinct learning groups, making it efficient to select entire classes, with Class VII A designated as the experimental group and Class VII B as the control group, each consisting of 32 students. The experimental group was taught using the 5E learning cycle model, enhanced by Classcraft, while the control group followed a discovery learning approach with the standard teaching materials used at the school.

Data collection was conducted using a test to assess students' problem-solving skills in both the control and experimental groups. The test was administered in two phases: before the treatment (pretest) and after the treatment (posttest). The test results were analyzed through the Kolmogorov-Smirnov normality test, homogeneity test, Independent Sample T-Test, and effect size analysis.

Result and Discussion

Based on the analysis of the problem-solving skills test data and collaboration skills questionnaire data, a comparison of results between the two classes was obtained, including normality testing, homogeneity testing, and hypothesis testing using IBM SPSS Statistics 25. The results of the problem-solving skills test and the collaboration skills questionnaire for the control class are presented in Tables 2 and 3.

Table 2. Description of Collaboration Questionnaire Scores

	Experiment Group		Control Group	
	Pre-Test	Post-Test	Pre-Test	Post-Test
Average	69.81	77.09	67.50	68.75
SD	14.042	10.316	7.531	7.535
Min	34	63	57	53
Max	99	99	95	86

Table 2 shows an increase in the average collaboration skills for the experimental class by 7.28%. A similar improvement occurred in the control class, although smaller, with an increase of 1.25%.

Table 3. Description of Problem-Solving Skills Data

	Experiment Group		Control Group	
	Pre-Test	Post-Test	Pre-Test	Post-Test
Average	33.28	76.09	30.78	65.78
SD	9.887	8.204	8.339	11.785
Min	15	60	15	40
Max	55	90	50	85

Table 3 shows an increase in the average science problem-solving skills for the experimental class by 42.81%. A similar improvement occurred in the control class, with an increase of 35%. Normality testing was conducted as a prerequisite for the parametric hypothesis test using the Independent Sample T-Test. The results of the normality test are presented in Tables 4.

Table 4. Normality Test Result of Collaboration Questionnaire and Problem-Solving Test

Class		Collaboration	Problem-Solving
		Sig	Sig
Pre-Test	Experiment	0.200	0.183
	Control	0.190	0.077
Post-Test	Experiment	0.196	0.175
	Control	0.200	0.200

Based on the results of the Kolmogorov-Smirnov test for collaboration skills and problem-solving skills in the experimental and control classes, the Sig. (2-tailed) value was greater than 0.05. According to the test criteria, if the Sig value is greater than 0.05, the data are normally distributed. Next, homogeneity testing was conducted to determine whether the data have equal variance. The results of the homogeneity test are shown in Table 5.

Table 5. Homogeneity Test for Collaboration

	Levene Statistic	df1	df2	Sig.
Based on Mean	3.506	1	62	.066
Based on Median	3.355	1	62	.072
Based on Median and with adjusted df	3.355	1	59.473	.072
Based on trimmed mean	3.322	1	62	.073

Based on Table 5, the significance value (Sig) Based on Mean is 0.66, which is greater than 0.05 for collaboration skills. Therefore, it can be concluded that the variance of the questionnaire data between the experimental and control classes is equal, or homogeneous.

Table 6. Homogeneity Test for Problem-Solving

	Levene Statistic	df1	df2	Sig.
Based on Mean	2.404	1	62	.126
Based on Median	1.466	1	62	.231
Based on Median and with adjusted df	1.466	1	59.884	.231
Based on trimmed mean	2.255	1	62	.138

Based on Table 6, the significance value (Sig) Based on Mean is 0.126, which is greater than 0.05 for collaboration skills. Therefore, it can be concluded that the variance of the questionnaire data between the experimental and control classes is equal, or homogeneous. The data were then further analyzed using the Independent Sample T-test with the IBM SPSS Statistics 25 program. A summary of the Independent Sample T-test results can be seen in Table 7.

Table 7. Independent Sample T Test Result

	T	Sig. (2-tailed)
Collaboration	2.002	0.000
Problem-Solving	3.640	0.001

Based on Table 7, the results of the independent sample t-test for students' collaboration skills before and after using the 5E learning cycle model assisted by Classcraft gamification show a significance (Sig) (2-tailed) value of 0.000 < (α) 0.05 for collaboration skills and 0.001 < (α) 0.05 for problem-solving skills. Therefore, it can be concluded that the 5E learning cycle model assisted by gamification significantly affects the collaboration and problem-solving skills of seventh-grade students.

Table 8. Multivariate Test Result

	F	Sig
Pillai's Trace	12.516	0.000
Wilks' Lambda	12.516	0.000
Hotelling's Trace	12.516	0.000
Roy's Large Root	12.516	0.000

Based on the results of the Hotelling's Trace test, a significance value of 0.000 < 0.05 was obtained. This indicates a significant difference in collaboration skills and science problem-solving skills between students taught using the 5E learning cycle model with Classcraft gamification and those taught using the conventional learning model. The effect size analysis was conducted using an effect size calculator available on the website, and the results are as follows.

Table 9. Effect Size Analysis Result

	Cohen's delta	Sample
Collaboration	0.90	32
Problem-Solving	1.01	32

Based on Table 9, the effect size analysis results indicate that the obtained Cohen's delta values are 0.90 for collaboration skills and 1.01 for problem-solving skills. Thus, both skills are categorized as having a very strong effect.

This study aims to investigate the impact of using Classcraft gamification within the 5E learning cycle model on ecology and biodiversity content to enhance collaboration and problem-solving skills among seventh-grade students in a public junior high school in Sleman, Yogyakarta. This quasi-experimental research employed a nonequivalent pretest-posttest control group design, with 32 students in Class VII A as the subject. The gamification media utilized was the Classcraft web platform, featuring science content aligned with the Merdeka Belajar curriculum.

During the exploration phase, the teacher formed groups of four students, encouraging them to engage in activities and answer questions within Classcraft quests. Each group comprised students with varying skill levels, promoting discussions and idea exchanges. This collaborative environment allowed students to independently explore concepts, fostering critical and creative thinking in problem-solving.

In the explanation phase, groups were tasked with organizing their exploration results, requiring collaboration to formulate conclusions and present information clearly. Representatives from each group presented their findings in the Classcraft assignment column, indirectly enhancing their problem-solving skills through simplified explanations and responses to classmates' inquiries. The teacher facilitated this process, guiding students toward summarizing new concepts and encouraging mutual respect for differing opinions.

The elaboration phase focused on applying newly acquired concepts to solve related problems. Students worked collaboratively to identify strategies, provide feedback, and create innovative solutions. They reflected on their problem-solving processes, with the teacher guiding them through each step and reinforcing concepts through group discussions. Finally, in the evaluation phase, students independently completed assessment questions in the Classcraft evaluation section. Their scores served as indicators of their understanding of ecology and biodiversity concepts, allowing students to track their progress and identify areas for improvement.

The 5E learning cycle model enhanced by Classcraft gamification was evaluated for its effectiveness in improving collaboration skills through pre- and post-learning questionnaires. The questionnaire included four collaboration indicators: task engagement, communication, effective and cooperative teamwork, and problem-solving efforts. The results revealed an average score of 69.81 before implementing the gamified 5E model, which increased to 77.09 after the learning intervention.

These results align with (Haratua et al., 2023; Wulandari et al., 2024), which indicate that during the exploration phase, students had the opportunity to work in groups to validate hypotheses, while in the explanation phase, they presented their discussion outcomes for peer feedback. This collaborative process significantly enhanced students' collaboration skills (Uz Bilgin & Gul, 2020). Additionally, the Classcraft gamification media provided points for correctly answered questions and engaging features, motivating students to collaborate for higher scores. (Rahma et al., 2023) also found that completing Classcraft quests helped students earn XP and Crystal, fostering collaboration by encouraging group members to maintain health and minimize penalties. Furthermore, (Wiyono et al., 2022) emphasized that gamification elements serve as a motivating factor, enhancing group members' confidence in learning. This suggests that student collaboration can be effectively developed with technological assistance (Yurtseven Avci et al., 2020). However, it is noted that incorporating gamification does not alter students' attitudes (Alomari et al., 2019; Shavab et al., 2021). The effectiveness of the 5E learning cycle model enhanced by Classcraft gamification in improving students' problem-solving skills in science was assessed using a valid pretest and posttest consisting of five essay questions.

The experiment class showed a significant increase of 42.81% in posttest scores compared to pretest scores, while the control class experienced a 35% increase. This finding aligns with (Cylindrica et al., 2021), which reported that students in the experimental class using the 5E learning cycle model achieved higher average posttest scores than those in the control class. Similarly, (Mubaid et al., 2019; Wulandari et al., 2024) indicated that the 5E learning cycle model enhances student engagement, positively influencing problem-solving skills.

In this study, prerequisite tests were met, allowing for the implementation of MANOVA to test the hypothesis for the third research question. The MANOVA results based on Hotelling's Trace involved two variables and met the criteria for normal distribution and homogeneity. The results showed Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root values of 0.000, indicating a significance level less than 0.05. Thus, the null hypothesis (H0) is rejected. It can be concluded that the use of Classcraft gamification in the 5E learning cycle model has a simultaneous effect on students' collaboration and problem-solving skills in science education.

Students using the 5E learning cycle model with Classcraft gamification demonstrated better collaboration and problem-solving skills compared to those using discovery learning with school-provided materials. This is evidenced by the higher average scores and percentages of collaboration and problem-solving skills among students utilizing the 5E learning cycle model with Classcraft gamification.

The collaboration and problem-solving skills of students using the 5E learning cycle model with Classcraft gamification are superior to those of students using discovery learning with school-provided materials. This is evidenced by the higher average scores and percentages in both collaboration and problem-solving skills among students employing the 5E learning cycle model with Classcraft gamification compared to those using discovery learning.

Sonny et al., (2023) state that the 5E learning cycle model effectively engages students, leading to improved scientific thinking skills. This fosters a desire for active participation in groups, enhances problem-solving skills, and deepens conceptual understanding (Amaliyah et al., 2023; Oktavia et al., 2022). Similarly, Haratua et al., (2023) found that the 5E learning cycle model effectively reduces student resistance to learning, facilitating collaboration and idea-sharing within projects. As a result, students remain motivated to learn through collaborative discussions in their groups.

Conclusion

Based on the analysis and discussion of the data presented, it can be concluded that the use of Classcraft gamification in the 5E learning cycle significantly influences the collaboration skills of seventh-grade junior high school students, with a significance value of $0.000 < 0.05$ and a strong effect size of 0.9. Furthermore, Classcraft gamification significantly affects students' problem-solving skills, indicated by a significance value of $0.001 < 0.05$ and a strong effect size of 1.01. The application of Classcraft gamification within the 5E learning cycle has a simultaneous effect on both collaboration and problem-solving skills, with a significance value of $0.000 < 0.05$, demonstrating a correlation between these two variables.

This research implies that integrating gamification into the learning process can enhance student engagement and skill development, particularly in collaboration and problem-solving. Educators should consider implementing gamified learning environments, like Classcraft, to foster active learning and teamwork among students. Moreover, the strong effect sizes suggest that such interventions can yield significant improvements in essential skills, which are crucial for students' academic and future professional success. As schools move toward more innovative and interactive teaching methods, adopting gamification strategies can also help meet the demands of 21st-century learning, promoting critical thinking and cooperation in educational settings.

Acknowledgments
The researcher would like to thank the Department of Natural Sciences Education, Faculty of Mathematics and Natural Sciences, Yogyakarta State University for granting research permission and thank all those who have helped during the research process.

Author Contributions
Author 1 conceptualized the research idea and served as the primary supervisor, guiding the project through all stages, overseeing product development, and ensuring effective data collection. **Author 2** led the product development, managed data collection using systematic methods, and conducted data analysis to extract meaningful insights. **Author 3** was responsible for writing, revising, and finalizing the manuscript, ensuring clarity and coherence. They also synthesized findings in the discussion section and managed the article layout to meet publication standards.

Funding
This research was funded by Faculty of Mathematics and Natural Science, Universitas Negeri Yogyakarta.

Conflicts of Interest
The authors declare no conflict of interest.

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