



The Effect Of Gamification Method On Students' Understanding Of Concepts On Food Chain Material In Social Natural Sciences in Elementary Schools

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Abstract

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Doi:

<https://doi.org/10.47435/ipdk.v11i01.4380>

This study aims to investigate the effect of the gamification method on students' conceptual understanding of "Food Chain" topics within the IPAS subject (Natural and Social Sciences) at SD Muhammadiyah Parepare. A quantitative approach with a quasi-experimental, nonequivalent control group design was employed. The population included all Muhammadiyah elementary schools in Parepare, while the sample was selected via purposive sampling, consisting of 35 fifth-grade students: 18 in the experimental group (Class V.B) and 17 in the control group (Class V.A). Data were collected through a validated 30-item multiple-choice test and analyzed using the Independent Samples T-Test. The results revealed a significance value (2-tailed) of 0.000 ($p < 0.05$), leading to the rejection of the null hypothesis (H_0) and the acceptance of the alternative hypothesis (H_1). It is concluded that the implementation of the gamification method significantly enhances students' conceptual understanding of food chain material. These findings suggest that gamification serves as an effective pedagogical tool to improve students achievement in elementary science education.

Keywords: *Gamification Method; Students Achievement; Food Chain; IPAS*

1. Introductions

Education is a planned and systematic effort to foster an active learning environment, enabling students to develop their potential to meet the challenges of an evolving era. In line with National Education Standards, the implementation of the *Kurikulum Merdeka* in Indonesia, as regulated by the Decree of the Minister of Education, Culture, Research, and Technology No. 56/M/2022, emphasizes essential material to create more relevant, in-depth, and meaningful learning. The curriculum serves as a strategic planning document that grants educators the flexibility to implement student-centered learning methods to cultivate critical and creative thinking competencies (Tuerah & Tuerah, 2023). Despite this comprehensive design, its field implementation effectiveness requires thorough evaluation, given the persistent gap between curricular targets and actual student competency achievements.

However, data from the 2022 Programme for International Student Assessment (PISA) indicates that scientific literacy among Indonesian students remains low, with a score of 383, significantly below the international average of 485 (OECD, 2023). This challenge has intensified following the integration of Natural and Social Sciences into a single subject, IPAS, at the elementary level, which demands pedagogical adaptation to ensure integrated concepts are fully



understood (Landong et al., 2024). Specifically, regarding "Food Chain" topics, many students struggle to identify inter-organism relationships because the learning process remains teacher-centered and reliant on rote memorization. Memorization without deep comprehension prevents students from distinguishing the roles of various organisms within a food chain (Wadi et al., 2024). This issue was confirmed through observations at SD Muhammadiyah Parepare, where learning activities are still dominated by textbooks and teacher-led instruction, resulting in limited student engagement and low conceptual understanding in IPAS.

Gamification has emerged as an innovative solution by integrating game elements, such as points, user levels, challenges, leaderboards, feedback, goals, and badges, to create interactive and engaging learning experiences (Ariani, 2020; Sukmawati et al., 2021). This method can stimulate student motivation, competition, enthusiasm, perseverance, and focus through game mechanics, making the learning process more enjoyable (Sultan et al., 2024). Although its application requires meticulous preparation, gamification has proven capable of providing broader creative spaces for students.

Previous studies have demonstrated that gamification can enhance motivation and overall learning outcomes (Nurchahyo et al., 2025; Rahmadania et al., 2025; Rostiani et al., 2023; Sultan et al., 2025). However, most of these studies still focus on affective aspects and general cognitive scores. In contrast, this study explicitly and deeply examines the effect of gamification on a more specific cognitive dimension: student conceptual understanding of Food Chain material within a Muhammadiyah elementary school environment. This focus is crucial, as conceptual understanding serves as the primary foundation for students to apply knowledge in real-world context.

Based on this background, this study aims to analyze the effect of implementing gamification methods on increasing students' conceptual understanding of Food Chain material in the IPAS subject at SD Muhammadiyah Parepare. The results of this study are expected to provide an empirical contribution to the development of innovative teaching methods at the elementary school level.

2. Method

This study is an *experimental research* employing a *quantitative approach* with a *quasi-experimental design*, specifically the *nonequivalent control group design*. This design involves two sample groups: an experimental class that receives the treatment and a control class that does not (Gay et al., 2019). In the initial stage, both groups are given a pre-test (O_1 and O_3) to measure the students' baseline ability before the intervention is implemented. Subsequently, the experimental group receives instruction using the gamification method (X_1), while the control group receives instruction without the gamification method (X_2). After the entire learning series is completed, a post-test (O_2 and O_4) is administered to determine the final outcomes of the students' conceptual understanding in both classes. Systematically, this study design refers to the model proposed by Gay et al. (2019) as follows:

Table 2.1 *Nonequivalent Control Group Design*

Group	Pre-test	Treatment	Post-test
Experimental	O_1	X_1	O_2
Control	O_3	X_2	O_4

Source: Gay et al. (2019)

Information:

X_1 = Treatment with the Gamification Method

X_2 = Treatment without the Gamification Method

O_1 = Pre-test (Experimental Group)



O₂ = Post-test (Experimental Group)

O₃ = Pre-test (Control Group)

O₄ = Post-test (Control Group)

The population for this study encompasses all Muhammadiyah Elementary Schools in Parepare City, including SD Muhammadiyah 1, SD Muhammadiyah 2, SD Muhammadiyah 3, SDIT Muhammadiyah KH. Ahmad Dahlan, and SD Utama Muhammadiyah 5. The study sample was selected using a *purposive sampling* technique, a *non-probability sampling* method based on specific criteria relevant to the study objectives. The designated sample consists of 35 fifth-grade students from SD Muhammadiyah 3 Parepare, divided into two groups: class V.B as the experimental group and class V.A as the control group.

The primary study instrument is a multiple-choice achievement test, which has been validated and tested for reliability to measure students' conceptual understanding of the "Food Chain" topic in the IPAS subject. The study procedure comprises three main stages: the administration of a pre-test, the implementation of the treatment (applying the gamification method to the experimental group), and a final post-test. Data obtained were analyzed using both descriptive and inferential statistics. The hypothesis was tested using an *independent samples t-test*. Prior to the hypothesis testing, prerequisite tests, comprising normality and homogeneity tests, were conducted using *IBM SPSS Statistics* software. These tests ensure the validity of the analytical results regarding the significant influence of the gamification method on students' conceptual understanding.

3. Result and Discussion

This study employs a *quasi-experimental research design* with a *quantitative approach*. The study utilizes a *nonequivalent control group design*, involving an experimental group and a control group as comparative subjects. The study was conducted at SD Muhammadiyah 3 Parepare. The primary data collection instrument consisted of learning achievement tests designed to measure conceptual understanding, administered in two stages: a pretest to assess baseline proficiency prior to intervention, and a posttest to evaluate the impact of the treatment.

The intervention applied to the experimental group involved the integration of gamification methods into Science and Social Studies (IPAS) instruction, specifically focusing on the topic of food chains. This aimed to analyze the effectiveness of game elements in enhancing students' conceptual understanding compared to conventional methods. Descriptive statistical analysis was employed to examine the score comparisons between the experimental group, which implemented the gamification method, and the control group. A summary of the pretest and posttest results for both groups is presented as follows:

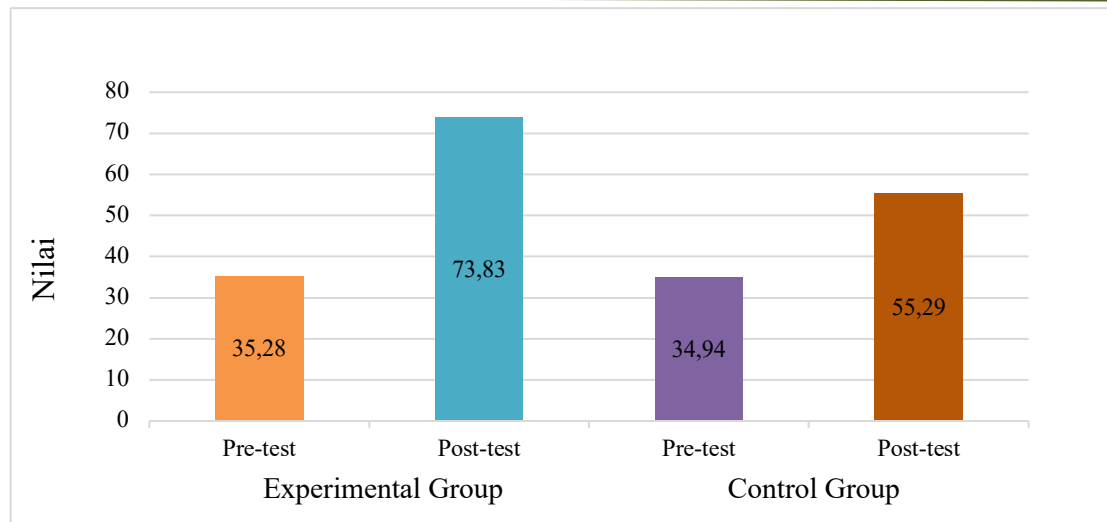


Figure 4.1 Average Score Diagram of the Experimental and Control Groups

Based on the results presented in the diagram, both groups exhibited an increase in their mean scores. However, a substantial and significant improvement was observed in the experimental group, which rose from 35.28 to 73.83. This increase serves as a strong preliminary indication that the implementation of gamification methods has a positive impact on conceptual understanding, as the final scores of the experimental group significantly outperformed those of the control group. In contrast, the control group, which received instruction without the integration of gamification, showed a more modest increase from 34.94 to 55.29. These results demonstrate that gamification is more optimal in fostering the enhancement of students' conceptual understanding compared to conventional approaches.

To determine the effectiveness of the treatment with precision and in quantifiable terms, a *Normalized Gain (N-Gain)* score analysis was conducted. The results of the *N-Gain* calculation, which represent the comparison of the improvement in abilities between the two groups, are presented in the following table:

Table 4.1 *N-Gain* Analysis Results

Group	Category	Frequency
Experimental	High	7
	Medium	11
	Low	0
Control	High	0
	Medium	10
	Low	7

Based on the *N-Gain* data analysis presented in the table, the results for both the experimental and control groups are classified into three categories: high, medium, and low. In the experimental group, 7 students achieved the 'high' category, 11 students were in the 'medium' category, and no students fell into the 'low' category. Conversely, in the control group, no students reached the 'high' category, while 10 students were in the 'medium' category and 7 students were in the 'low' category. The *N-Gain* results indicate that the experimental group had a higher number of students achieving superior *N-Gain* scores compared to the control group. These findings support the study hypothesis, which posits a significant difference between the class



implementing gamification methods and the one that did not. Consequently, it can be concluded that the independent variable had a significant effect on the dependent variable.

Prior to conducting hypothesis testing through inferential statistics, prerequisite analyses were performed, including normality and homogeneity tests. The normality test aims to ensure that the study data are normally distributed, which is a requirement for employing parametric statistics (Rosalina et al., 2023). Given that the sample size in this study is relatively small ($n < 50$), the *Shapiro-Wilk* test was utilized due to its higher sensitivity for limited sample sizes. The testing criteria were set at a significance level of $\alpha = 0.05$, where data are declared normally distributed if the significance value (*p-value*) is ≥ 0.05 . Conversely, if the obtained significance value is < 0.05 , the data are categorized as not normally distributed. A summary of the normality test results for both pretest and posttest data is presented in the following table:

Table 4.2 Results of the *Normality Test*

Variable	Group	Statistic	df	Sig. (<i>p-value</i>)
Conceptual Understanding	Experimental (Pre-test)	0.912	18	0.092
	Experimental (Post-test)	0.934	18	0.232
Conceptual Understanding	Control (Pre-test)	0.943	17	0.353
	Control (Post-test)	0.906	17	0.087

Based on the results of the normality test presented in the table, the significance values (*p-values*) for both the pretest and posttest scores in the experimental and control groups are all greater than the significance level of 0.05. Consequently, it can be concluded that the data for each group are normally distributed.

In addition to fulfilling the assumption of normality, another prerequisite for data analysis that must be met is the homogeneity of variance test. This test aims to ensure that the samples drawn from the population possess equal or homogeneous variances, thereby ensuring the validity of the comparison between the experimental and control groups. In this study, the homogeneity test was conducted using *Levene's Test for Equality of Variances* at a significance level of $\alpha = 0.05$. The decision-making criteria for the homogeneity test are as follows: if the significance value (*p-value*) is > 0.05 , the data variance is declared homogeneous. Conversely, if the significance value is < 0.05 , the data variance is considered non-homogeneous. Based on the data processing results using SPSS, a summary of the homogeneity test is presented as follows:

Table 4.3 Results of the *Homogeneity of Variance Test*

Variable	Sig. (<i>p-value</i>)	Conclusion
Conceptual Understanding	0.248	Homogeneous

Based on the results of the *homogeneity test* presented in the table, a significance value of 0.248 was obtained. A significance value greater than 0.05 in *Levene's Test for Equality of Variances* indicates that there are no significant differences in variances between the data groups. Consequently, the data can be declared to have homogeneous variances, confirming that the assumption of homogeneity of variance for further analysis has been met.

Once all prerequisite tests were fulfilled, the next step was to conduct hypothesis testing to draw statistical conclusions regarding the effect of the independent variable on the dependent variable. In this study, hypothesis testing was performed using the *Independent Samples T-Test*. The testing criteria were defined as follows: if $t_{\text{count}} > t_{\text{table}}$ or the significance value is ≤ 0.05 , there is a significant difference between the class implementing the gamification method and the one that is not. This implies that the independent variable has a significant effect on the dependent variable, leading to the rejection of the null hypothesis (H_0). Conversely, if $t_{\text{count}} \leq t_{\text{table}}$ or the



significance level is > 0.05 , the independent variable does not have a significant effect, and H_0 is accepted. Based on the data analysis conducted using SPSS software, the *t-test* results are as follows:

Table 4.4 Results of Hypothesis Testing (*Independent Samples T-Test*)

Conceptual Understanding	Equal Variances Assumed	<i>F</i>	<i>Sig.</i>	<i>t</i>	<i>df</i>	<i>Sig. (2-tailed)</i>
		3.455	0.072	7.217	33	0.000

Based on the results of the *Independent Samples T-Test* presented in the table, the significance value (*Sig. 2-tailed*) was found to be 0.000, which is ≤ 0.05 . This indicates a significant difference between the group implementing the gamification method and the group that did not. Consequently, the independent variable exerted a significant effect on the dependent variable, leading to the rejection of the null hypothesis (H_0). Furthermore, the manual *t-test* analysis revealed that the t_{count} value (7.217) is greater than the t_{table} value (1.692) at the corresponding degrees of freedom. Therefore, the null hypothesis (H_0) is rejected, confirming the effectiveness of the intervention.

3.1 Overview of Students' Conceptual Understanding in the Experimental Class

Descriptive analysis of the conceptual understanding in the experimental class (IV.A) demonstrated a significant upward dynamic. Pre-test data revealed that the students' average score prior to the intervention was 35.28 (highest score: 53; lowest: 23). This baseline condition indicates that students' understanding of Science and Social Studies (IPAS) material was not yet optimal, likely due to the dominance of conventional, teacher-centered learning models (Wadi et al., 2024). Aligning with the arguments of Amran & Arismunandar (2025), learning environments with minimal interaction and recreational elements often fail to build a solid conceptual foundation due to limited active student engagement.

Following the implementation of the gamification method, the average post-test score in the experimental class surged to 73.83 (highest score: 87; lowest: 60). This intervention was carried out by systematically integrating game elements, including points, badges, challenges, leaderboards, avatars, levels, goals, timers, feedback, rewards, and surprises. The novelty of this study lies in the classroom organization into three groups based on learning styles (Visual, Auditory, and Kinesthetic) in a balanced composition. Each learning stage was designed to accommodate students' sensory needs through competitive visual, auditory, and kinesthetic activities.

Theoretically, the integration of these elements aligns with the perspectives of Ariani (2020) and Naufal et al. (2024), which suggest that gamification creates an enjoyable learning experience through game mechanics within a non-game environment. These results reinforce the findings of Sukmawati et al. (2021) and Julianto & Ekohariadi (2020) regarding the effectiveness of gamification elements in the instructional process. The significant improvement in the experimental class (from 35.28 to 73.83) compared to the control class (from 34.94 to 55.29) proves that gamification is substantially more effective in fostering a deep understanding of IPAS concepts at the elementary school level.

3.2 The Effect of Gamification on Students' Conceptual Understanding

Hypothesis testing using the *Independent Samples T-Test* provided empirical confirmation of the descriptive findings above. Statistical analysis via SPSS version 27 yielded a value of $t_{count} = 7.217$ with $df = 33$ and a significance value (*Sig. 2-tailed*) of 0.000. Given that $Sig. < 0.05$ and $t_{count} > t_{table}$ ($7.217 > 1.692$), the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1)



is accepted. This clearly demonstrates a significant difference in conceptual understanding between the class implementing the gamification method and the control class.

Pedagogically, this substantial effect is driven by the psychological stimulation generated by the adopted game elements, such as badges, points, challenges, leaderboards, avatars, levels, goals, timers, feedback, rewards, and surprises. Psychologically, these elements stimulate enthusiasm, competition, and engagement among students (Sultan et al., 2025). Consequently, a learning process that incorporates such recreational components encourages students to become more active, thereby driving optimal conceptual understanding.

These findings confirm the effectiveness of gamification in accelerating conceptual understanding while reinforcing the empirical consistency established by Rostiani et al. (2023) and Rahmadania et al. (2025) regarding the superiority of this method over conventional approaches. Mechanistically, the integration of game elements in learning does not merely serve as an affective stimulant to increase motivation and activity, as suggested by Nurcahyo et al. (2025) and Sultan et al. (2024). More importantly, the gamification elements in this study were proven to reduce students' cognitive load when processing procedural material. This indicates that gamification acts as a cognitive scaffolding that assists students in organizing information more systematically and deeply.

The novelty of this study lies in the localization and specification of the cognitive dimensions examined. While previous literature has tended to evaluate learning outcomes generically or focused on the affective domain, this study explicitly proves that gamification has a significant impact on specific IPAS conceptual understanding, particularly regarding food chains. The focus on elementary students at SD Muhammadiyah Parepare provides a practical contribution: game elements are not merely edutainment instruments, but rather an instructional strategy capable of transforming abstract material into concrete learning experiences. Thus, these findings offer a more measurable implementation model for improving students' conceptual understanding at the elementary level, while simultaneously filling the literature gap in testing specific cognitive dimensions within IPAS subjects.

4. Conclusion

This study concludes that the implementation of the gamification method exerts a positive and significant influence on enhancing students' conceptual understanding of Science and Social Studies (IPAS), specifically regarding the food chain material at SD Muhammadiyah Parepare. Statistically, this effectiveness is confirmed by the hypothesis test results, which yielded a significance value of 0.000, indicating a distinct difference in cognitive achievement between the experimental and control classes. The average score increase in the experimental class, reaching 73.83, which significantly outperformed the control class at 55.29, demonstrates that the integration of gamification elements successfully transforms procedural material into a deeper conceptual grasp.

Based on these findings, it is recommended that educators consistently implement gamification methods, particularly for topics with high cognitive complexity, to ensure sustainable conceptual development. Furthermore, schools should support this ecosystem through policies focused on teacher competency development in designing interactive instructional models. For future researchers, it is suggested to explore the effectiveness of gamification on a broader scale, such as in different subject areas or by incorporating moderating variables like digital literacy, to strengthen the generalizability of these findings within a more heterogeneous educational context.



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JURNAL **Pendidikan Dasar dan Keguruan**

Volume 11, No. 1, 2026

P-ISSN: 2527-578X

E-ISSN: 2715-2818

Homepage: <https://journal.uiad.ac.id/index.php/JPDK/index>

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