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Improving Critical Thinking Skills of Elementary School Students: Project Based Learning vs Gamification-Based Group Investigation

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ABSTRAK

Prestasi pendidikan Indonesia di kancah internasional masih tergolong kurang maksimal. Pembelajaran di sekolah pada umumnya yang masih belum banyak meninggalkan pembelajaran konvensional menjadi salah satu penyebabnya. Sangat penting untuk menghadirkan inovasi dalam pendidikan Indonesia khususnya dalam proses pembelajaran di sekolah dengan berbagai kreativitas seperti mengimplementasikan keterpaduan antara model dan pendekatan pembelajaran. Tujuan dari penelitian ini adalah untuk membandingkan keterampilan berpikir kritis siswa yang memperoleh pembelajaran dengan model PjBL berbasis gamifikasi dengan siswa yang memperoleh pembelajaran denggan model GI berbasis gamifikasi. Jenis penelitian ini adalah penelitian eksperimen yakni eksperimen kuasi dengan desain penelitian nonequivalent control group design. Subyek dalam penelitian ini terdiri dari siswa kelas V pada dua sekolah dasar negeri berbeda dengan jumlah masing-masing siswa yakni 25 dan 26 orang. Pengumpulan data dilakukan dengan kegiatan pretest dan posttest menggunakan istrumen soal sebanyak 20 butir soal. Data yang terkumpul dianalisis menggunakan uji Independent Sample T-Test dan uji N-Gain. Hasil analisis data menunjukkan bahwa persentase efektivitas dari model PjBL berbasis gamifikasi lebih besar dari persentase efektivitas dari model GI berbasis gamifikasi (56,2890 > 53,4372). Hasil tersebut menunjukkan bahwa model PjBL berbasis gamifikasi lebih efektif terhadap keterampilan berpikir kritis siswa dibandingkan dengan model GI berbasis gamifikasi. Hanya saja perbedaan tersebut tidak tampak secara signifikan.

ABSTRACT

Indonesia's educational achievements in the international arena are still classified as less than optimal. Learning in schools in general, which has not abandoned conventional learning, is one of the causes. It is very important to present innovation in Indonesian education, especially in the learning process in schools, with various creative approaches, such as implementing integration between learning models and approaches. The purpose of this study was to compare the critical thinking skills of students who received learning using the gamification-based PjBL model with those of students who received learning using the gamification-based GI model. This type of research is experimental research, namely a quasi-experimental research design with a non-equivalent control group design. The subjects in this study consisted of fifth grade students at two different public elementary schools with a total of 25 and 26 students respectively. Data collection was carried out through pretest and posttest activities using a questionnaire of 20 questions. The collected data were analyzed using the Independent Sample T-Test and the N-Gain test. The results of data analysis show that the percentage of effectiveness of the gamification-based PjBL model is greater than the percentage of effectiveness of the gamification-based GI model (56.2890 > 53.4372). These results indicate that the gamification-based PjBL model is more effective at improving students' critical thinking skills compared to the gamification-based GI model. It's just that the difference does not appear to be significant.

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1. INTRODUCTION

Critical thinking is one of the high-level thinking skills and is an important competence that needs to be developed (Alsaleh, 2020; Muhammadiyeva et al., 2020). Critical thinking skills are crucial to be trained in students from an early age, especially starting in primary school through the learning process (Nababan & Aminah, 2017; Sutarsa & Puspitasari, 2021). Critical thinking is a way of making decisions based on reasonable, logical, and acceptable reasoning (Prihatmanto et al., 2020; Wicaksono et al., 2017). Critical thinking can be developed through several indicators, including providing simple explanations, with sub-indicators such as focusing on questions, analyzing arguments, and asking challenging questions, building basic skills, with sub-indicators such as assessing the credibility of a source, observing and evaluating observations, making inferences, with sub-indicators including making deductions and evaluating the results of deductions, and making inductions and evaluating the results of inductions, making and determining decisions, providing further explanations, consisting of sub-indicators such as identifying terms and definitions, and identifying assumptions, and strategizing and tactics, consisting of sub-indicators such as determining actions and interacting with others (Pahrurrozi, 2019; Sularmi et al., 2018; Tamara, 2018). When students' critical thinking reaches a high level, it indirectly affects their learning process, enabling them to compete to achieve maximum results (Rusdiana & Sucipto, 2018).

The use of critical thinking skills indirectly stimulates active student engagement in learning activities such as observation, information analysis, thinking development, consideration, decision-making, reference determination, and evaluation (Asalaei et al., 2020; Sianturi et al., 2018). However, the reality in the field shows that Indonesia's dream of achieving international achievements is still hindered by the fact that Indonesian education is not yet at its maximum level and is still lagging behind (Alifah, 2021). Education in educational institutions has also not shown significant changes and is still comfortable with conventional learning conditions (Nababan & Aminah, 2017; Tanjung & Nababan, 2018). Competencies such as critical thinking skills are difficult to grow and develop in students if learning is still conducted with unchanged designs that do not adapt to ongoing developments. Students already possess critical thinking tendencies that need to be enhanced through various treatments and accommodations in learning. Learning should be concrete, especially in examining topics and issues close to students' lives, so that from learning activities, students can understand concepts and at the same time develop problem-solving skills in both learning activities and daily life. Observations and interviews conducted at SDN Mojolangu 3 and SDN Tunjungsekar 1 show that students in the learning process and activities are not yet maximizing their ability to process and analyze the information they receive, so they are hesitant to express opinions, often provide answers based on memorization without relating them to the situation they are experiencing, struggle to provide answers with supporting arguments, and are not yet efficient in making decisions and finding solutions to problems. In reality, students have these competencies within them but need further training and development, which affects their lower learning outcomes. There are many strategies that can be employed to develop and train students' critical thinking skills from an early age, which should be aligned with the current curriculum standards and characteristics in Indonesia. Efforts to improve the quality of education and learning, especially in enhancing critical thinking skills, can be achieved by implementing various learning models (Haeruman et al., 2017; Hartini, 2017)

Innovative models such as project-based learning (PjBL) and the Group Investigation (GI) model are often chosen as strategies to address these issues (Pahrurrozi, 2019; Sularmi et al., 2018). Both of these models are frequently used in the learning process, particularly in stimulating and training students to think critically (Fitri et al., 2018; Hartini, 2017; Issa & Khataibeh, 2021; Kartikawati & Pratama, 2017; Rusdiana & Sucipto, 2018). Learning with the PjBL model allows students to explore and experience learning experiences that are in line with the scientific concepts they need to learn and has a significant and sustained impact on students' competencies (He et al., 2023; Noelia, 2020). Critical thinking skills, as one of the competencies that students should possess, increase and become higher after being taught with the PjBL model (Latifah et al., 2020; Listiqowati et al., 2022). The PjBL or project-based learning model has a unique feature compared to other models, in that it involves students in investigating issues or topics through projects they undertake. This makes learning interesting and provides students with a different experience in developing their critical thinking skills (Issa & Khataibeh, 2021; Markula & Aksela, 2022; Sularmi et al., 2018). Unlike the PjBL model, one of the learning models closely related to and frequently used by teachers is the cooperative learning model. Cooperative learning has characteristics such as students learning together with their peers and working collaboratively in groups, students in diverse and varied groups, teacher supervision and facilitation of learning activities, and group assessment as the main focus (Abdullah, 2017; Hasanah & Himami, 2021). Cooperative learning comprises various models, and one that is also interesting and proven to enhance students' critical thinking skills is the Group Investigation (GI) or group investigation model (Kartikawati & Pratama, 2017; Tamara, 2018; Wicaksono et al., 2017).Learning with the GI model focuses on learning activities that place students in

information search activities through learning sources related to the learning material, such as mass media, books, the internet, and more (Pratami et al., 2019; Zorlu & Sezek, 2019). Starting from the planning stage, students actively participate, for example, by selecting and determining themes and methods for learning through investigation activities. With this learning activity, students actively participate, are trained and accustomed to communicate, respect others' opinions, and follow systematic learning procedures within the group (Ainiyah et al., 2022; Tamara, 2018).

The PjBL and GI models have distinctive features that set them apart from other models. Each model, PjBL and GI, has its own systematic syntax or steps in its implementation. Given the characteristics of learning, especially at the primary school level, where students often get bored and are more interested in learning that includes games or challenges, one way to make these innovative learning models more engaging and effective, while providing enjoyable learning experiences for students, is to integrate a gamification approach. Gamification is the application and adoption of game features or components in areas outside of games with the aim of providing motivation and interest (Paľová & Vejačka, 2022). Implementing learning using gamification features can provide a more effective, efficient, and motivating learning experience for students to achieve maximum learning outcomes (Chapman & Rich, 2018; Suci et al., 2017). The concept of gamification applied to learning has also been shown to develop students' critical thinking skills (Martí-Parreño et al., 2021; Nurbaiti et al., 2021). Several previous studies have shown differences in students' critical thinking skills before and after receiving PjBL model-based learning on temperature and heat topics, with an increase in students' critical thinking abilities (Sumardiana et al., 2019). Other research has shown that the implementation of the Group Investigation model can improve social studies learning outcomes on the theme "My Ambition" (Pratami et al., 2019). Further research has revealed that students' mathematical critical thinking skills and their improvements are better in the Group Investigation model compared to the Project Based Learning model (Sutarsa & Puspitasari, 2021). Based on these research findings, it can be said that both the GI and PjBL models significantly enhance students' critical thinking skills. However, previous research did not specifically focus on improving primary school students' critical thinking skills through project-based and group investigation-based gamified learning. This study is focused on this area to examine the effects of the PjBL model and the GI cooperative learning model with gamification on primary school students' critical thinking skills.

2. METHOD

This research uses a quantitative research method with an experimental design known as a quasi-experiment. Experimental research involves accommodating specific treatments for one class in the study, while the other class receives natural or typical treatments, and in the end, the results of the special treatment given are measured. However, in this research, both classes (experimental class 1 and experimental class 2) will receive treatments, which are learning using gamified-based Project-Based Learning (PjBL) and gamified-based Group Investigation (GI) models. These treatments will then be compared to determine which of the two treatments has a more significant impact on critical thinking skills. The design or quasi-experimental design used is the Nonequivalent Control Group Design. The research begins with problem formulation, reviewing relevant theory and previous research, selecting research subjects, determining data collection techniques, developing research instruments, collecting data, and analyzing the collected data. The subjects in this research are fifth-grade students from two different schools, namely, the fifth-grade students of SDN Mojolangu 3 and SDN Tunjungsekar 1 in the academic year 2022/2023. There are 25 students in the experimental class 1 at SDN Mojolangu 3 and 26 students in the experimental class 2 at SDN Tunjungsekar 1. The sample in this research comprises the entire population, referred to as a saturated sample because the population in this study is not very large. Data collection in this research is carried out using a test technique. The test technique is chosen as the method for data collection because the competency being measured is critical thinking skills, which can only be assessed and improved through scoring or students' performance on the test questions. The test consists of 20 multiple-choice reasoning questions that are designed based on predefined indicators and guidelines. The pretest and posttest questions cover the same material but with different sentence formulations and question constructions. The instrument test validation criteria can be seen in Table 1.

Table 1. Test Instrument Validation Matrix

No	Assessed Aspects
1	**Question Format:** The test questions are clearly formatted, making assessment easier.
2	**Question Contents:** Clarity of work instructions. Questions are formulated briefly and clearly. The suitability of the questions with the learning material. Conformity of questions with indicators (learning objectives to be achieved) and stimulate students to think critically. Ask questions according to the situation / reality Give reasons for arguing Make decisions/conclusions Presenting assumptions or views Define solutions Appropriateness of the level of difficulty and depth of material with the development of elementary school students. The subject matter does not point to the correct answer. Images or text as a form of stimulus to questions are clear and easy to understand.
3	**Language and Writing:** Use good and correct Indonesian Easy to understand language
4	**Benefits of Critical Thinking Skills Test Questions:** Can be used to measure the success of learning (in research)

The test instrument that has been developed was validated by experts with expertise in the field, namely an education evaluation expert and an elementary school teaching material expert. Through the validation process, notes and improvements were obtained before the instrument was assessed and deemed suitable for research purposes. The feedback provided included improvements in the layout of illustration sentences and questions in the test, detailed problem situations in the test items, and the use of language appropriate for elementary school students. The test questions were also subjected to item analysis and have been tested for validity, reliability, difficulty level, and discrimination, ensuring that the questions used as research instruments are of high quality. After the revision and item analysis processes, the instrument was declared suitable for use in research. Students will complete the test questions at the beginning (pretest) and at the end (posttest) of the learning activities. The data from the pretest and posttest will be compared, analyzed, and tested to obtain research results. The analytical techniques used to process the collected data are both descriptive and inferential statistics. Descriptive statistics will depict the averages and standard deviations of the pretest and posttest results for experimental classes 1 and 2. For inferential statistics, prerequisite tests will be conducted, including normality testing using the Shapiro-Wilk test and data homogeneity testing using the Levene test, followed by hypothesis testing.

3. RESULT AND DISCUSSION

Result

The analysis in this research is conducted through descriptive and inferential analysis. Descriptive analysis includes the analysis of subjects and research variables, as well as the analysis of pretest and posttest data. Inferential analysis consists of normality testing, homogeneity testing, and hypothesis testing.Firstly, the descriptive analysis begins with an analysis of the research subjects and variables. The data collected during the research activities consists of assessments from pretests (given before learning) and posttests (given after students have undergone the learning process), which are quantitative data. The scores that students can obtain in both the pretest and posttest activities range from a minimum of 0 to a maximum of 100. The research subjects are divided into two classes based on the teaching model and approach. The gamified-based Project-Based Learning (PjBL) model will be implemented in experimental class 1, comprising 25 students, while the gamified-based Group Investigation (GI) model will be implemented in experimental class 2, comprising 26 students. The percentage of students between the two classes is relatively equal, with 49.02% in one class and 50.98% in the other. After analyzing the subjects and research variables, the analysis proceeds to test the pretest

and posttest data on students' abilities. The pretest data analysis shows that the average score obtained in experimental class 1, which underwent the gamified-based PjBL model learning process, is 59.50 with a standard deviation of 6.12. In experimental class 2, which implemented the gamified-based GI model, the pretest score was 54.71 with a standard deviation of 6.53. When comparing the posttest data to the pretest data, an increase in the average scores is observed. In experimental class 1, which implemented the gamified-based PjBL model, there was an improvement, resulting in an average posttest score of 82.20. Meanwhile, in experimental class 2, which implemented the gamified-based GI model, an increase was also observed, resulting in an average posttest score of 79.32. Therefore, it can be concluded that there was an improvement in critical thinking skills in both classes after receiving the treatments, whether it was through the gamified-based PjBL model or the gamified-based GI model. The initial and final scores of students' critical thinking skills in each class, whether in experimental class 1 or experimental class 2, will be analyzed to determine if there is a significant difference in the critical thinking skills of students who underwent learning with these two different models and approaches. However, before conducting the testing, the data must go through prerequisite tests, which include normality testing and homogeneity testing.

Secondly, inferential statistical tests begin with the normality testing of data. The research data that is available will be analyzed to determine whether it follows a normal distribution, which is one of the requirements for hypothesis testing. Normality testing in this study uses the Shapiro-Wilk test due to the sample size being less than 100. The results of the normality testing for the pretest data of critical thinking skills in experimental groups 1 and 2, implementing the gamified-based PjBL and gamified-based GI models respectively, yield probability levels of 0.324 and 0.256. These probability levels are greater than 0.05 (0.324 > 0.05 and 0.256 > 0.05), indicating that the pretest data in the two different classes follow a normal distribution. The results of normality testing for the posttest data of critical thinking skills in both classes also yield probability levels of 0.125 and 0.706, which are greater than 0.05 (0.125 > 0.05 and 0.706 > 0.05), indicating that the posttest data also follow a normal distribution. In addition to having data that follows a normal distribution as a prerequisite for hypothesis testing, the research data must also be tested for homogeneity. Homogeneity testing is conducted on both the pretest and posttest data for experimental groups 1 and 2. The homogeneity test uses the Levene test. The results of the homogeneity test in this research show a probability level of 0.223, which is greater than 0.05 (0.223 > 0.05). Therefore, it can be stated that the pretest and posttest data for experimental group 1 with the gamified-based PjBL model and experimental group 2 with the gamified-based GI model are homogenous.

Finally, the concluding analysis in this research involves hypothesis testing to determine whether the hypotheses or provisional answers formulated by the researcher based on the theoretical review and previous research can be accepted or rejected. The prerequisite testing conducted earlier has shown that the research data follows a normal distribution and is homogeneous, allowing for hypothesis testing using parametric statistics. Hypothesis testing is performed using the Independent Sample T-Test to determine the difference in students' final skills after undergoing the learning process between experimental class 1 and experimental class 2. The results of the Independent sample t-test can be seen in Table 2.

Table 2. Results of an Independent Sample T-Test

		F	Sig.	Q	Df	Sig. (2-tailed)	Mean Differences	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Critical Thinking Skills of Students	Equal variances assumed	1.522	0.223	1.373	49	0.176	2.8731	2.0931	-1.3331	7.0793
	Equals variances not assumed			1.369	47.354	0.178	2.8731	2.0992	-1.3492	7.0954

The results of the independent sample t-test in Table 2 indicate that the significance value, with an F-value of 1.52, is 0.176. This significance value is greater than 0.05 (0.176 > 0.05). Based on these results, it can be stated that there is no significant difference between the final abilities (critical thinking skills) of students in experimental class 1, who underwent learning using the gamified-based PjBL model,

and students in experimental class 2, who used the gamified-based GI model. Since the Independent Sample T-Test results show no significant difference, it is necessary to further test which of the two models being compared is more effective. To do this, testing with the N-Gain test is conducted. The results of the N-Gain test can be seen in Table 3.

Table 3 .N-Gain Test Results

No	Results of the N-Gain Score Calculation	
	Experiment 1	Experiment 2
Average	56.2890	53.4372
Minimum	21.43	25.00
Maximum	87.50	86.96

The results shown in Table 3 indicate that the scores or percentages of effectiveness for both models and approaches to learning fall into the moderate or reasonably good criteria because the scores or percentages obtained range from 31-70% (56.2890 and 53.4372). Then, when comparing the scores or percentages of these two models, the effectiveness percentage of the gamified-based PjBL model is higher than the effectiveness percentage of the gamified-based GI model (56.2890 > 53.4372). This means that the gamified-based PjBL model is more optimal and effective compared to the gamified-based GI model.

Discussion

The result of the independent sample t-test indicates that there is no significant difference between the two types of learning in terms of students' critical thinking skills. Therefore, an N-Gain test was conducted to determine which gamification-based learning model had the greatest influence or effectiveness on the development of students' critical thinking skills. The results obtained indicate that both learning models and approaches can be categorized as having a moderate level of influence or effectiveness; in other words, they are quite effective. Both learning models and approaches engage students actively in the learning process, starting with the orientation phase, where the teacher provides an overview of the learning process, including projects and investigations. Additionally, gamification features such as challenges, scores, badges, and leaderboards are incorporated. Throughout the planning and scheduling of activities, students are encouraged to provide their opinions and ideas based on their perspectives. Opinions and reasons are emphasized throughout the learning process as they are considered the foundation for accountability in the choices or decisions made (Arinda et al., 2019; Latifah et al., 2020; Rahardjanto et al., 2019). Students are also consistently asked to express their opinions based on the situations and conditions they experience in their daily lives. From the opinions or viewpoints provided, students are guided towards reaching collective decisions.

Presentation activities, whether for products or reports, train students to express their assumptions and viewpoints after successfully completing projects or investigations. Through presentation activities, students can develop self-confidence and learn from the performances of their peers. Students feel that their hard work is appreciated and valued because their results are showcased collectively or presented in front of the class. Presentation activities also provide an opportunity for self-reflection for students on whether their work and performance have been optimal or not, thus serving as a learning experience for both strengths and weaknesses (Sojayapan & Khlaisang, 2020). The learning stages in both of these models also encourage students to develop other competencies, such as communication and collaboration skills, with both teachers and peers. It fosters creativity in finding innovations and new approaches to solving problems, formulating and asking questions, and critical thinking in responding to various situations encountered (Nurdin, 2021; Walsh & Dalton, 2022). Skills like creating initial plans, considering alternative plans, problem-solving within groups, and strategizing to be the quickest and most accurate in tackling challenges, among others, provide valuable learning experiences (Prihatmanto et al., 2020; Wicaksono et al., 2017). In addition to cognitive skills, students' attitudes and physical skills are also developed during the learning process. For instance, attitudes such as respecting others' opinions, responsibility, independence, and honesty, as well as practical skills like writing, formulating questions, searching for information, and even practical skills like planting, sawing, cutting, and other motor skills, are honed through these learning activities. The characteristics of both learning models are actually quite similar, but the focus of the PjBL model on project-based learning is quite different from the usual learning activities that students typically engage in. Project activities have distinct characteristics compared to regular learning. These characteristics include scheduling projects within a specific time frame, adjusting the project's difficulty level to match the subject matter and students' developmental stage, conducting projects related to real-life conditions or issues experienced, and interacting with people around them, which is crucial when completing the project, whether it's with

groupmates or when seeking guidance from the teacher. In project-based learning, students are also trained to make their own choices and decisions (Markula & Aksela, 2022; Revelle et al., 2020). On the other hand, the investigation aspect of the GI model of learning also has its uniqueness. It involves implementing a learning style that includes conducting investigations to find answers and solve problems experienced by students (Pratami et al., 2019; Zorlu & Sezek, 2019). Students learn in small groups formed at the beginning of the learning process and engage in various activities and stages collectively, particularly in gathering information and problem-solving (Ainiyah et al., 2022; Ambarita et al., 2019).

Students in combined PjBL and GI learning models, enhanced with gamification, eagerly anticipate, discuss, and experience meaningful learning experiences, leading to a high level of enthusiasm during the learning process. Students become more motivated and engaged in learning activities due to the competition to overcome challenges (Paľová & Vejačka, 2022). Furthermore, the gamification approach integrated into the learning process plays a significant role in stimulating high motivation among students to participate in learning activities and reinforces the comprehension of concepts and materials. This is because all the challenges students undertake are closely related to the learning content. Moreover, this approach is considered highly suitable for elementary school learning as it creates an enjoyable and non-stressful learning environment. Gamification has a substantial impact on the delivery of content and knowledge in education (Folgieri et al., 2019; Huang et al., 2020; Nurtanto et al., 2021).

The results obtained in this study align with previous research findings, which also revealed differences in students' critical thinking skills before and after receiving PjBL model-based learning on the topic of temperature and heat, indicating an improvement in students' critical thinking abilities (Sumardiana et al., 2019). Other research results have shown that the implementation of the group investigation learning model can enhance the learning outcomes in Social Studies for the "My Aspirations" theme (Pratami et al., 2019). Furthermore, subsequent research findings indicate that students' mathematical critical thinking abilities and their improvement were better in the Group Investigation learning model compared to the Project Based Learning model (Sutarsa & Puspitasari, 2021). Therefore, based on these various research findings, it can be concluded that both the GI and PjBL learning models significantly enhance students' critical thinking skills.

4. CONCLUSION

The conclusion drawn from the process and results of the research is that students have shown improvement in their critical thinking skills. Initially, these skills were less than optimal, but they experienced changes and enhancements after going through the learning process implemented with both the gamified Project-Based Learning (PjBL) model and the gamified Group Investigation (GI) model. There was no significant difference in students' critical thinking skills between experimental class 1, which implemented the gamified PjBL model, and experimental class 2, which implemented the gamified GI model. The gamified PjBL model showed an advantage over the gamified GI model in terms of its effectiveness in developing critical thinking skills in elementary school students. The presence of game features and challenges as part of the gamification approach also made learning much more enjoyable, allowing students to engage in the learning process with enthusiasm and high motivation.

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