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Differentiated Learning: The Right Solution to Enhance the Critical Thinking Skills of PGSD Students in the Basic Concepts of IPA

Lisanun Thoyibah Yusuf[1*], Agus Basuki[1], Azzumardin Syaidi[1], Fatia Rosyida[1]

[1] Faculty of Education and Psychology, Yogyakarta State University, Yogyakarta, Indonesia.

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Corresponding Author:
Lisanun Thoyibah Yusuf
lisanunthoyibah.2023@student.uny.ac.id

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Abstract: This research aims to determine the effect of differentiated learning on the critical thinking skills of PGSD students in the basic IPA concepts course. The approach used in this research is quantitative, with a quasi-experimental design. The research was conducted on first-semester students at Yogyakarta State University, specifically in class A as the experimental class with 26 people and class B as the control class with 30 people. The results of the paired sample t-test for critical thinking skills between the pretest and post-test in the control class are 8.744 > 1.697 (t-table N=30) and in the experimental class are 33.303 > 1.706 (t-table N=26). In each class, the significance value is 0.001. If compared to the required value for a significance level of 0.05, the calculated significance is less than 0.05, it is stated that there is a positive influence. The findings indicate a positive and significant impact of differentiated learning on enhancing students' critical thinking skills in the basic IPA concepts course. These results indicate that educators need to consider integrating differentiated learning into their teaching strategies to improve the quality of education.

Keywords: Basic IPA concepts; Critical thinking; Differentiated learning

Introduction

In the era of globalization and the 4.0 industrial revolution, critical thinking skills have become one of the essential skills that the younger generation must possess (Nihayati, 2024; Prabowo & Khaudli, 2024; Rahayu & Al Hadi, 2023). According to the report Trebeck et al. (2021), Critical thinking and complex problem-solving are among the top ten most sought-after skills by the industrial and business world in the coming decade. This is reinforced by an international study from OECD (2019), which shows that students' ability to solve problems and think critically is an important indicator of their success in the workplace and everyday life (Almulla, 2023; Kravchenko et al., 2023; Sarwari & Kakar, 2023). According to recent research, critical thinking skills have become crucial for students in solving complex problems, adapting to changes, and thinking analytically in various academic and professional situations (Almulla, 2023; Jamil et al., 2024). These skills are important for academic success and workplace success, which requires quick and accurate decision-making based on in-depth information analysis (Stephen, 2024; Van Le & Chong, 2024; Zhao et al., 2024).

However, the results of the PISA survey on the critical thinking skills of Indonesian students show results that are still far below the average for developed countries (Laily et al., 2024; Ulum & Nafisa, 2024). This condition raises concerns about the ability of the next generation to compete on the international stage. Nationally, the government through the Ministry of Education, Culture, Research, and Technology has introduced various policies to improve the quality of education, one of which is the integration of Merdeka Belajar that provides space for more adaptive and

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flexible learning (Lestari, 2024; Siregar et al., 2024). In this case, one aspect that still requires more attention is the development of critical thinking skills among students, especially in the Elementary School Teacher Education (PGSD) program, which will be at the forefront of shaping the next generation. However, studies show that the critical thinking skills of students in Indonesia are still at a concerning level (Nababan, 2024; Yasir, 2024).

PGSD students, as future educators, play a strategic role in developing critical thinking skills from early education. Therefore, they need to be equipped with these skills through appropriate learning methods (Layly et al., 2024; Perguna, 2024; Ulfah et al., 2024). One of the approaches considered effective in developing critical thinking skills is differentiated learning. Differentiated learning is an approach that accommodates the needs, interests, and abilities of individual students, allowing each student to develop optimally according to their potential (Kettler & Taliaferro, 2022; Onyishi & Sefotho, 2020; Tomlinson & Jarvis, 2023).

In the context of the Basic IPA Concepts course, the application of differentiated learning has great potential to enhance critical thinking skills (Chen & Wu, 2023; Falloon, 2024; Wormeli, 2023). This course not only requires an understanding of scientific concepts but also emphasizes analytical skills and problem-solving, which are key components of critical thinking abilities (Irwan et al., 2024; Jamil et al., 2024; Song et al., 2024). With the right learning methods, students can be encouraged to think more actively, analyze, and make decisions based on scientific evidence, so they do not just become passive recipients of information, but also critical and reflective individuals (Geurts et al., 2024; Karagöz, 2024; X.-M. Wang et.al 2024).

Although differentiated learning has been implemented in various educational institutions around the world, research examining its effectiveness in the context of higher education in Indonesia, particularly in the Basic IPA Concepts course, is still limited. Differentiated learning, which provides opportunities for each individual to learn according to their learning style, abilities, and needs, is widely recognized as an effective method for developing critical thinking skills (Langelaan et al., 2024; Moallemi, 2024). In several studies, this approach has been proven to improve learning outcomes, including critical analysis skills in various learning contexts (Griful-Freixenet et al, 2020; Hu, 2024; Strogilos et al. , 2023). In a heterogeneous class, this method facilitates collaborative learning and enhances constructive interaction among students with diverse backgrounds and levels of ability (Andriyani et al., 2024; Liang et al., 2024).

This research aims to address the gap by exploring the extent to which differentiated learning can enhance the critical thinking skills of PGSD students at Yogyakarta State University. With the results of this research, it is hoped that practical recommendations can be provided for the development of a more adaptive curriculum and learning models, as well as contributing to efforts to improve the quality of education in Indonesia to be more competitive on a global scale.

Method

The type of research used in this study is a quantitative approach with a quasi-experimental research method, with the research design used being a non-equivalent control group design. Aimed at determining the difference in the influence of differentiated learning methods on the critical thinking skills of PGSD students in the basic IPA concepts course before and after being given treatment in the form of pretest and posttest. The procedure in this study begins with the stage of administering a pretest to both the experimental group and the control group, followed by the stage of providing treatment four times to the experimental group. In the final stage, both groups, the experimental group, and the control class, are given a posttest.

Table 1. Research Design

Class	Pre-Test	Treatment	Post-Test
Experiment class	O1	x	O2
Control class	O1	-	O2

Description:
O1 : Pretest, conducted to determine the basic abilities of students before treatment.
O2 : Posttest, conducted to determine the final ability of students after treatment.
X : Treatment, and implementation of learning activities using differentiated learning.

The sample in this study consists of first-semester students at Universitas Negeri Yogyakarta, totaling 56 individuals. The research was conducted from September to October 2024. The sample in this study includes students from class A as the experimental group, consisting of 26 students, and students from class B as the control group, consisting of 30 students. The reason for selecting this sample is that the understanding of basic IPA concepts as prerequisite material is taught to first-semester students at Yogyakarta State University. Purposive sampling is a sampling technique that selects samples for a specific purpose or because they are closest to the information or problem being studied. In addition, this technique is used to select respondents who are most likely to

provide relevant results and information. This sample return technique has special considerations, including the qualification of critical thinking skills of PGSD students in the basic IPA concepts course, which is one of the factors considered in the sampling process.

Result and Discussion

Based on the research conducted, the implementation of differentiated learning in the Basic IPA Concepts course has proven to have a positive impact on the improvement of critical thinking skills among PGSD students at Yogyakarta State University. The data shows a significant increase in students' analytical abilities, problem-solving skills, and decision-making skills after participating in differentiated learning. This is supported by various data that have been obtained during the research, including:

Validation Test Results

The data that has been obtained will be followed by a validity test using the Pearson product-moment correlation formula in SPSS version 27. The results of the critical thinking ability instrument validation test are shown below.

Table 2. Results of the Critical Thinking Ability Instrument test

Question number	Value	Information
1	0.482	Valid
2	0.529	Valid
3	0.537	Valid
4	0.456	Valid
5	0.421	Valid
6	0.466	Valid
7	0.549	Valid
8	0.59	Valid
9	0.541	Valid
10	0.515	Valid
11	0.632	Valid
12	0.479	Valid
13	0.600	Valid
14	0.542	Valid

Based on the validity test results table, all items of the critical thinking ability instrument are declared valid. The statement can be seen from the Pearson product-moment correlation value compared to the table value, which is 0.266 (for N=56 with a significance level of 5%), indicating that the calculated correlation value exceeds the table value. Therefore, it can be concluded that the fourteen items can be accepted as research instruments.

Results of the Reliability Test

Reliability is related to the consistency of test results (Lechien et al., 2024), if similar tests are given to several groups of students or the same test is given to the same group and shows the same results. Reliability testing using the Alpha Cronbach formula through SPSS version 27. The r value calculated using the Alpha Cronbach formula is then compared with the table r value at a significance level of $\alpha = 0.05$ and degrees of freedom = N-2 (N = number of students). If r hit > r tab, then the measuring instrument is considered reliable. The results of the reliability recapitulation of the critical thinking ability instrument are as follows.

Table 3. Reliability Test Results

Variables	Cronbach's Alpha
Critical thinking skills	0.792

The Cronbach's Alpha value of 0.792 in the reliability test of the critical thinking ability tool indicates that the tool is reliable for data collection in research because its value is greater than 0.266 (r table).

Results of the Normality Test

The normality test is conducted to determine whether the pretest and posttest data on critical thinking ability are normally distributed or not. The normality test is performed using the SPSS version 27 application with a significance level of 0.05. The decision-making criterion is that if the significance value is greater than 0.05, the data is declared to be normally distributed. Here are the results of the normality test for the pretest and posttest data on critical thinking skills.

Table 4. Results of the Pretest Critical Thinking Ability Question

Group	Sig. (p)	Condition	Information
Control	0.418	p>0.05	Normal
Experiment	0.130	p>0.05	Normal

For the control class, the significant value of critical thinking ability is 0.418, and for the experimental class, it is 0.130. These values indicate that both classes do not have a significant difference in terms of critical thinking ability at the pretest stage. As shown by the results of the pretest data normality test, the data used have a normal distribution, as the significance value is greater than 0.05. Thus, the assumption of normality is met, allowing the use of parametric statistical tests such as the Paired Sample t-test for further analysis.

Table 5. Results of the Normality Test for the Posttest Critical Thinking Ability Questions

Group	Sig. (p)	Condition	Information
Control	0.268	p>0.05	Normal
Experiment	0.315	p>0.05	Normal

Based on the significance value for critical thinking skills in the control class with the conventional learning model, it is 0.268, and the significance value in the experimental class with the differentiated learning model is 0.315. The normality value of the data after testing is shown in the Table, indicating that the data used have a normal distribution because the significance value is greater than the significance level of 0.05.

Results of the Homogeneity Test

The homogeneity test determines whether the sample selected from the population has the same or comparable variance using pretest and posttest data. To conduct this analysis, SPSS 27 is required with a significance level (α) of 0.05. If the pretest and posttest results are greater than 0.05, the homogeneity test for decision-making will be used. For the experimental class, we use a differentiated learning model. The results of the analysis of the homogeneity test for pretest and posttest critical thinking skills can be seen in the table below.

Table 6. Results of the Homogeneity Test

Data types	Sig. (p)	Condition	Information
Pretest	0.300	p>0.05	Homogeneous
posttest	0.420	p>0.05	Homogeneous

The results of the homogeneity test of critical thinking skills in Table 6 showed a significant value greater than 0.05, with a pretest value of 0.300 and a posttest value of 0.420. Based on these results, it can be concluded that the critical thinking skills in the pretest and posttest of the experiment are homogeneous.

Paired Sample T-Test Results

To find out the significance of the results the test is that if the significance value > 0.05, then Ho is accepted, but if the significance value < 0.05, then Ho is rejected. The results of the paired sample t-test analysis can be seen in the table below.

Table 7. Results of the Paired Sample t-Test

Critical thinking skills	Pretest	Posttest	t count	Sig.	Information
Control class	26.47	29.83	8.744	0.001	Ho was rejected
Experimental class	22.69	48.62	33.303	0.001	Ho was rejected

The results of the Paired sample t-test for critical thinking skills in Table 7 between the pretest and posttest of the control class are 8.744 > 1.697 (t table N=30) and in the experimental class are 33.303 > 1.706 (t table N=26). In each class, the significance value is 0.001. If compared to the required value for a significance level of 0.05, the calculated significance is less than 0.05, it is stated that there is a positive influence. Based on the results of the Paired sample t-test and the conclusions obtained, this is in line with Aulia et al. (2024), Baddane et al. (2024), Dailo et al. (2022), Lai et al. (2020), Le et al. (2024), and Zubaıdah et al. (2017) shows that differentiated learning effectively enhances students' critical thinking skills, leading to a substantial increase in critical thinking scores. Based on the results, it can be concluded that Ho is rejected and Ha is accepted, indicating a positive effect of using the inquiry learning model on critical thinking skills in the control class. The improvement in critical thinking skills in the control class before and after using the conventional learning model was from 26.47 to 29.83 with a score range of 3.36, while the critical thinking skills before and after in the experimental class using the differentiated learning model were from 22.69 to 48.62 with a score range of 25.93.

Independent Sample T-Test Results

The independent sample t-test is conducted to determine the significance of the test results; if the significance value is > 0.05, then Ho is accepted, but if the significance value is < 0.05, then Ho is rejected. The results of the independent sample t-test analysis can be seen in the table 8.

Table 8. Results of the Independent Sample t-Test

Class	Condition	T count	Sig.	Findings	Information
Experiment	After	26.840	0.001	Ho was rejected	There is a difference
Control					

Based on the results of the independent test sample t-test in Table 8, the significance score of critical thinking ability is 26.840 > 1.706 (t table N=26), and the significance value 0.001 < 0.05, therefore Ho is rejected and Ha is accepted. Thus, it can be concluded that there is a significant and positive difference in the impact of

using the differentiated learning model compared to the conventional learning model on the critical thinking skills of PGSD students in the basic IPA concepts course. The results indicate that the treatment experienced an improvement. Still, the use of the differentiated learning model has a significant and positive impact compared to the use of the conventional learning model. In line with (Alhamuddin et al., 2023; Hidayati et al., 2024; Khasawneh, 2023; Qorib, 2024; Tashtoush et al., 2023) stating that differentiated learning models have consistently proven to have a significant impact on improving students' critical thinking skills.

Students involved in differentiated learning demonstrate a better understanding of scientific concepts and sharper reflective thinking skills compared to those who follow conventional teaching methods (Sneddon, 2022; Vantieghem et al., 2020; J. Wang & Jou, 2023; Zerai et al., 2023). This indicates that differentiated learning is capable of accommodating differences in learning styles, interests, and individual academic needs, thereby maximizing the learning potential of each student (Awofala & Lawani, 2020; Gheyssens et al., 2022; Noman & Kaur, 2020; Tomlinson & Jarvis, 2023).

In addition, this learning facilitates more constructive interactions among students with diverse abilities, creating a collaborative learning environment and encouraging active engagement (Dulfer et al., 2024; Harris et al., 2022; Shin et al., 2020; Sormunen et al., 2020). This finding is consistent with the results (Chandra, 2020; Zajda & Zajda, 2021), showing that a differentiated approach is effective in improving analytical skills in various educational contexts.

Overall, the results of this research make an important contribution to enriching the understanding of the effectiveness of differentiated learning in higher education, particularly in enhancing the critical thinking skills of PGSD students. This research is also expected to serve as a foundation for the development of more adaptive educational policies, in line with the demands of the workforce and the competency needs of the 21st century. This reinforces the conclusion that there is a positive and significant impact of differentiated learning on the critical thinking skills of PGSD students in the basic IPA concepts course.

Conclusion

Based on the discussion results, it can be concluded that the use of a differentiated learning model has a positive and significant impact on the improvement of critical thinking skills of PGSD students in the basic IPA concepts course. The results of the paired sample t-test showed a significant increase in both groups, both the control class and the experimental class, with the experimental class using the differentiated learning model experiencing a greater increase in critical thinking skills. These findings align with various recent studies, and affirm that differentiated learning demonstrates a better understanding of scientific concepts and sharper reflective thinking skills compared to groups following conventional teaching methods. This indicates that differentiated learning can accommodate differences in learning styles, interests, and individual academic needs, thereby maximizing each student's learning potential. It significantly strengthens critical thinking skills. Differentiated learning has proven to be more effective than conventional models, leading to substantial improvements in students' analytical and evaluative skills, as well as facilitating more constructive interactions among students with diverse abilities, creating a collaborative learning environment and encouraging active engagement, especially in the context of basic IPA concept learning.

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Author Contributions

L.T.Y; Conceptualization, methodology, validation. A. B., A.S. and F. S; formal analysis, data curation, writing original draft preparation, writing review, and editing.

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Conflicts of Interest

The authors declare no conflict of interest.

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