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The Effectiveness of Teaching Materials with TEE Patterns in Improving Students' Critical Thinking Skills and Scientific Attitudes

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Abstract

Qualified and compatible teaching materials are one of the most economical and practical instruments for developing critical thinking skills and scientific attitudes. This study aims to obtain a valid and effective Pancasila and Civic Education Basic Concept teaching material design to improve students' critical thinking skills and scientific attitudes. The materials developed are with the TEE pattern (T = Task, E = Explanation, E = Evaluation). The development followed ten stages: a preliminary study, planning, developing drafts, validating drafts, revising drafts, first field trial, revising based on the results of the first field trial, second field trial, revising based on results of the second field trial, and disseminating teaching materials. The research sample was determined through a random sampling technique. In testing the validity and effectiveness of the product, the trial design used was a quasi-experimental pretest-posttest with a nonequivalent control group design. Data were collected using critical thinking test instruments and questionnaires and were analyzed using inferential statistical analysis (independent sample t-test). The research findings show that; (1) Pancasila and Civic Education teaching materials with TEE pattern are effective in improving students' critical thinking skills and scientific attitudes; (2) there are significant differences in critical thinking skills and scientific attitudes between research subjects in the experimental class and the control class. Based on these findings, using teaching materials with the TEE pattern can improve students' critical thinking skills and scientific attitudes.

Keywords: Teaching materials with TEE patterns, critical thinking skills, scientific attitude, university students..

Introduction

The complexity of problems and information technology growth in the 21st-century demand better competence than in previous centuries. The 2016 Ontario discussion document states that three categories or competency domains must be developed: cognitive, interpersonal, and intrapersonal. The three domains consist of 50 competencies, where 13 competencies are included in the cognitive domain, 15 in the interpersonal domain, and 22 in the intrapersonal domain. However, of the many competencies above, the most important competencies in the international framework that benefit every life aspect are critical thinking, communication, collaboration, and creativity & innovation (Ontario, 2016:11). In the 2010 Pacific Polacy Research Center document (2010:1), there are 4 categorizations of 21st-century skills: digital literacy, thinking of discovering, effective communication, and high productivity. From these two documents, it is clear that the similarities in the expected competencies of the 21st century determine a person success. Based on those documents, 5 main competencies of the 21st century can be formulated into critical thinking, communication, creativity and innovation, collaboration, and digital literacy.

In addition to the five basic 21st-century competencies above, other aspects that need to be improved are mastery of learning materials/outcomes and scientific attitudes. Although these two aspects are not the main competencies of the 21st century, these are essential as well. According to Piaget (Slavin, 2000:52), knowledge determines the breadth and depth of a person's actions and attitude. Therefore, education that encourages mastery of knowledge must be the learning outcome (Sumardi, et al., 2020; Irwanto, et al., 2023, Wahyudiati, et al., 2019).

Moreover, from the 2018 PISA results, Indonesia is still ranked 70th out of 78 countries being studied (Harususilo, 2019). Of the 3 areas assessed, such as reading, mathematics, and science, the results of Indonesian students are still below the minimum competency (Ministry of Education and Culture of the Republic of Indonesia, 2019). According to the TIMSS rating, Indonesian students' aptitude is ranked 44th out of 44 nations (Sriyatun, 2020).

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These accomplishments are consistent with the Global Human Capital Report, which reveals that Indonesia ranks 65th out of 130 countries in the world for educational quality, far behind other nations (Wahyudi et al., 2022).

This condition is certainly still far from the target expected by the ministry. Likewise, with a scientific attitude, this aspect is vital because it increases a person's rationality and systematic ability to solve various problems (Prabowo, 1992:30). In addition, scientific attitudes also directly affect problem-solving skills (Demirel, Derman, & Karagedik, 2015), learning outcomes (Brown, et al. 2015; Irwanto, et al., 2023), and students' critical thinking (Wahyudiati et al., 2022).

Previous studies showed that students are still low in some 21st-century competencies. For example, several findings indicated that students need to be improved in the aspect of critical thinking skills. This condition is illustrated by Rasmawan (2017), who found that the critical thinking skills of Untan students were in the "low" category. Similarly, Kirana and Kusairi's (2019) findings at the State University of Malang pointed out that students' critical thinking skills are also in the low category. As for scientific attitude capability, Cahyani et al. (2014) found that 43.28% of research subjects have a low scientific attitude. It is also similar to Wahyudiati's (2020) findings that the quality of the scientific attitude of UIN Mataram students is still low.

Furthermore, another finding uncovered that students' critical thinking skills and scientific attitudes must be systematically and continuously improved. It can use teaching materials that could facilitate these competencies' growth and development. According to Hanifah (2014), teaching materials are one of the dominant factors determining the quality of learning processes and outcomes, including critical thinking skills and scientific attitudes. Fredriksen, Brar, & Trucano (2015) emphasized that teaching materials are the most efficient instrument for improving education quality apart from teachers' quality. So, quality and compatible teaching materials can be a solution to enhance critical thinking skills and scientific attitude.

Not every teaching material effectively improves students' critical thinking skills and scientific attitudes. Only those designed for specific problems that are compatible could be its solution. Therefore, this research seeks to develop teaching materials to improve students' critical thinking skills and scientific attitudes. It is a Pancasila and Civic Education Besic Concept teaching material with a TEE pattern that consists of; T = Task, E = Explanation, and E = Evaluation. In the Task (T) section, students would be presented with assignments they must complete before they learn the material. The tasks given are in the form of problems or analytical questions. The Explanation (E) section contains argumentative explanations about the material being studied so that they will understand the concept logically and critically. Meanwhile, the Evaluation (E) section contains instruments to measure student mastery of the material. The results of these measurements are used as a basis for providing remedial and enrichment. The teaching material model with the TEE pattern is believed to improve students' critical thinking skills and scientific attitudes. It is supported by Karim (2015) and Wahyudiati (2020), who found that problem-based learning effectively increases students' critical thinking and scientific attitudes.

Substantively, this research seeks to accurately find the teaching materials' design/scheme which supports the development of critical thinking skills and scientific attitudes. Since it has never been initiated, the developed TEE is a novel teaching material pattern.

Based on the description above, the research questions formulated are; 1) how is the design of Pancasila and Civic Education teaching materials with a TEE pattern can improve students' critical thinking skills and scientific attitudes; 2) what are the differences in critical thinking skills and scientific attitudes between students who use teaching materials with the TEE pattern and students who use conventional teaching materials; 3) how big is the contribution of teaching materials with a TEE pattern to students' critical thinking skills and scientific attitudes.

METHOD

Research Design

This experimental study adopted a nonequivalent quasi-experimental design pretest-posttest control group design **(**Cresswell, 2009:113). Control and experimental classes were determined by random sampling techniques. Treatment in the experimental group used teaching materials with a developed TEE pattern, while the control group used teaching materials that followed the conventional pattern. More clearly, the research design is illustrated in Table 1.

Table 1: The nonequivalent pretest and posttest control group design.

Groups	Pretest	Treatment	Posttest
Experimental	Critical thinking skills and scientific attitudes	Learning using teaching materials with TEE patterns	Critical thinking skills and scientific attitudes
Control	Critical thinking skills and scientific attitudes	Learning using conventional teaching materials	Critical thinking skills and scientific attitudes

Research Sample

The research sample comprised 60 students at the University of Mataram, consisting of 30 students for the experimental group and 30 for the control group. Samples were randomly selected from two classes determined purposively. A complete description of the research subjects is illustrated in Table 2.

Tabel 2: Characteristic of research sample

Characteristics		Experimental Group		Control Group	
		N	%	N	%
Genders	Female	20	67%	19	63%
	Male	10	33%	11	37%

Research Instrument

The data were collected through critical thinking skills and scientific attitude instruments. Student critical thinking skills data consists of 5 indicators, namely, elementary clarification (EC), bases for a decision (BD), inference (I), advanced clarification (AC), and supposition and integration (SI) which was adapted from Mundilarto & Ismoyo (2017). Each indicator consisted of two items, so the total number of items on the critical thinking skills test was 10 questions. The test measured students' critical thinking skills before and after learning. The highest score for each item on critical thinking skills was 4 (descriptors: correct answers and strong arguments supporting each reasoning indicator with facts, concepts, and laws). The lowest score was 0 (no answer given). The scoring criteria were converted into equations and interval categories for critical thinking skills, as in Table 3. Critical thinking skills were measured based on indicator parameters (RSi) and individual parameters (RSs).

Table 3: Critical thinking skills criteria according to RSi and RSs parameters

Critical Thinking Skills Criteria	Interval score RSi	Interval score RSs
Excellent	RSi > 3.21	RSs > 25.60
Good	2.40 < RSi ≤ 3.21	19.20 < RSs ≤ 25.60
Fair	1.60 < RSi ≤ 2.40	12.80 < RSs ≤19.20
Poor	0.80 < RSi ≤ 1.60	6.41 < RSs ≤12.80
Very Poor	RSi ≤ 0.80	RSs ≤ 6.41

The scientific attitude questionnaire was adapted from Wahyudiati (2019) with modifications consisting of 4 aspects: attitude towards scientific inquiry, application of scientific attitude, curiosity, and open-mindedness. A complete description of the aspects and indicators of a scientific attitude is shown in Table 4.

Table 4: Blueprint of Scientific Attitudes Instrument

No	Aspects	Indicator	Item
1	Attitude to scientific inquiry (SA1).	1. Enthusiastic in conducting scientific investigation activities	1, 2, 3
		2. Interested in exploring information related to the Pancasila and Civic Education through scientific inquiry	4, 5, 6, 7
2	Application of scientific attitudes (SA2)	1. Prioritizing aspects of truth and honesty in completing tasks	8, 9, 10, 11, 12
		2. Persistent and meticulous in completing tasks	13, 14, 14, 16, 17
3	Curiosity (SA3)	1. Have a scientific interest in the Pancasila and Civic Education	18, 19, 20
		2. Interested in information related to the Pancasila and Civic Education	21, 22, 23
4	Open-minded attitude (SA4)	1. Willingness to listen to the opinions of others	24, 25, 26, 27
		2. Interested in exploring more comprehensive information	28, 29, 30

The questionnaire was formulated using the Likert scale with five levels: strongly disagree, disagree, slightly disagree, agree and strongly agree. Maximum score = 5 and minimum score = 1 (applies to negative and positive statement items). The scoring results based on these criteria were converted into interval equations and categories, as illustrated in Table 5.

Table 5: Scientific Attitudes Criteria

Loving the culture criteria	Mean range
Low	0-1.67
Average	1.68-3.34
High	3.35-5.00

Before being used, two instruments were validated by two experts from the University of Mataram, Indonesia. Cronbach's alpha coefficient for the critical thinking test was $\alpha = 0.85$, and the scientific attitude questionnaire was $\alpha = 0.87$. This value exceeded the minimum criterion of 0.70 (Hair et al., 2010). Based on the test results, it can be concluded that the two instruments proved to be valid and reliable.

Data Analysis

Students' critical thinking skills and scientific attitudes were analyzed quantitatively using inferential statistics, an independent sample t-test. This technique was used to determine differences in improving students' critical thinking skills and scientific attitudes in both classes with a significance value of 0.05 ($p < 0.05$). To determine the increase in the score (N-gain) refers to the formulation put forward by Hake

(Wahyudiati, 2023). Analysis of research data was preceded by a normality test ($p > 0.05$) using the Kolmogorov-Smirnov test (because the sample group members were higher than 50). Statistical analysis was done by using the SPSS 24.0 program.

Findings And Discussion

Critical Thinking Skills

Critical thinking skills are one of the most important competencies for students (Stephenson & Sadler-McKnight, 2016; Villafane & Lewis, 2016). In a learning context, critical thinking skills greatly determine student academic achievement (Stupple et al. 2016). Nowadays, it is beneficial not only in academic and work contexts but also for solving various problems in everyday life. Therefore, educational institutions, especially universities, must focus on developing these skills. Universities highlight what needs to be known and develop transversal skills such as critical thinking (Franco, Costa, & Almeida, 2018). One of the instruments that can be used to improve students' critical thinking skills is teaching materials oriented towards developing these competencies. Teaching materials that can potentially develop students' critical thinking skills are teaching materials with a TEE pattern.

Based on the analysis, it is known that the teaching material model is effective in improving students' critical thinking skills. Its effectiveness can be seen from the analysis of indicator parameter data (RSi), the analysis of individual parameter data (RSs), and the results of research hypothesis testing. The results of the data analysis of the experimental class and the control class are seen from the indicator parameters (RSi) in Table 6, the results of individual parameter data analysis (RSs) are described in Table 7, and the results of the research hypothesis test are illustrated in Table 8 below.

Table 6: Students' critical thinking skills based on the indicator parameters (RSi)

Group	N	Score	CTS Indicator					RSi average	Category
			EC	BD	I	AC	SI		
Experimental	30	Pretest	1.13	1.14	1.75	1.60	1.65	1.45	Poor
		Posttest	3.30	3.40	3.35	3.38	3.41	3.37	Good
		N-gain	0.76	0.79	0.71	0.74	0.75	0.75	High
Control	30	Pretest	1.19	1.16	1.55	1.55	1.5	1.39	Poor
		Posttest	1.53	1.53	1.75	1.75	1.82	1.68	Poor
		N-gain	0.12	0.13	0.08	0.08	0.13	0.11	Low

Table 7: Students' critical thinking skills based on individual parameters (RSs)

Group	N	Critical thinking skills score and category				N-gain	Category
		Pretest	Category	Posttest	Category		
Experimental	30	10.52	Poor	32.62	Excellent	0.75	High
Control	30	10.58	Poor	15.23	Fair	0.16	Low

Table 8: Hypothesis test results of students' critical thinking skills, $p < 0.05$

Value	Critical Thinking Skills	T-test		
		T	df	Sig 2 tailed
Standard N-Gain	Equal variances assumed	13.412	48	0.000
	Equal variances not assumed	13.412	24.265	0.000

Table 6 displays an increase from the pretest to the posttest according to the RSi criteria. The highest increase was in the BD and EC for the experimental group, followed by the AC, SI, and I indicators. The Rsi average in the experimental class increased from 1.45 (poor) pretest to 3.37 (good) on the posttest. The average N-gain increase in the experimental class in the RSi parameter was 0.75, with excellent criteria. In the control group, the highest increase occurred in the BD indicator, and the lowest score was in indicators I and AC. In the average RSi control class, there was no significant increase where the average pretest RSi was 1.39 (poor) to 1.68 in the posttest, which stays in the same category (poor). Likewise, the average N-gain increase in the control class on the RSi parameter was only 0.11 (very poor). The data proves that from the indicator parameters (RSi), the use of teaching materials with the TEE pattern can significantly improve students' critical thinking skills.

As for Table 7, the individual parameters (RSs) of the critical thinking skills of experimental class students experienced a very significant increase after given treatment using teaching materials with the TEE pattern. It can be seen from the pretest score of the experimental class of 10.52 (poor), which increased to 32.62 (excellent), and the N-gain value of 0.75 (high). In contrast to the experimental class, there was no significant increase in the control class, where the pretest score was 10.58 (poor) and only increased to 15.23 (fair), and the N-gain value was 0.16 or low in the category.

Meanwhile, Table 8 shows that Pancasila and Civic Education teaching materials with the TEE pattern effectively improve students' critical thinking skills. It is illustrated by the calculated t-value, which is less than 0.05. This analysis also proves that the design of teaching materials developed is more effective in developing students' critical thinking than conventional ones. So, it is clear that Pancasila and Civic Education teaching materials with a TEE pattern could improve students' critical thinking skills.

The effectiveness of teaching materials with the TEE pattern in improving students' critical thinking skills is inseparable from the teaching materials' characteristics. Students must do three activities to improve their critical

thinking: doing assignments, studying the material, and answering questions. Tasks were the first step of each subject matter in teaching materials with a TEE pattern that students must complete. Students could not proceed to the next stage without completing this section. In the Task step, students were asked to solve a problem. Through these activities, their critical thinking skills would be formed. It could happen because in problem-solving, there are analytical thinking processes, synthesizing, assessing information, and interpretation processes, all of which can develop critical thinking skills (Khusniati et al., 2017; Suardana et al., 2018). This opinion supports the results of research conducted by Uzunoz & Demirhan (2017) and Wahyudiati & Qurniati (2022) that problem-solving in the learning process can improve critical thinking skills. Wahyudiati, et al. (2022) stated that critical thinking is an essential component of the problem-solving process.

Furthermore, the second and third activities in the problem-based textbook with the TEE explanation and evaluation pattern have contributed to developing students' critical thinking. The Explanation section provides opportunities for students to interact with the material by exploring the material. These exploratory and interactive activities could improve their critical thinking skills (Setiawan et al., 2017; Dewi et al., 2021). Similar to Yildirim & Özkahraman-Koç's (2018) opinion, critical thinking skills can be developed by learning more profoundly about the material.

The evaluation stage also affects students' critical thinking skills. The activity of answering questions drives students to think and formulate answers. This activity leads to the development of their critical thinking skills. This argument confirms Zulfaneti, Edriati, & Mukhni's (2018) findings that assessment instruments contribute to developing students' critical thinking skills. If the three activities in teaching materials with the TEE pattern are repeated or trained, students' critical thinking skills will develop well (Yildirim & Özkahraman-Koç, 2018).

Scientific Attitude

A scientific attitude is a person's tendency to act systematically by using the scientific method to solve problems or respond to phenomena (Prabowo, 2015). It is a skill to help deal with life problems, including gaining knowledge (Wahyudiati, 2020). It needs an effective way to develop it. One instrument that has proven effective in developing students' scientific attitudes is Pancasila and Civic Education teaching materials using the TEE pattern.

The effectiveness of Pancasila and Civic Education teaching materials with the TEE pattern in shaping students' scientific attitudes can be seen from the data analysis of each indicator and the results of the research hypothesis. The results of the data analysis of each indicator of scientific attitude are illustrated in Table 9, while the results of the research hypothesis data analysis are illustrated in Table 10.

Table 9: The data of Students' Scientific Attitudes based on indicator

Group	N	Score	Loving the Culture Indicators				Mean range	Category
			SA1	SA2	SA3	SA4		
Experimental	30	Pretest	2.51	2.72	2.52	2.65	2.6	Average
		Posttest	4.32	4.33	4.35	4.41	4.35	High
		N-gain	0.73	0.71	0.74	0.75	0.73	High
Control	30	Pretest	2.33	2.23	2.25	2.23	2.26	Average
		Posttest	2.91	2.92	2.73	2.92	2.87	Average
		N-gain	0.22	0.25	0.17	0.25	0.22	Low

Table 10: The Results of the Students' Scientific Attitude Hypothesis test using sample t-test, $p < 0,05$

Value	Scientific Attitude	T-test		
		T	Df	Sig 2 tailed
Standard n-Gain	Equal variances assumed	12.169	48	0.000
	Equal variances not assumed	12.169	29.045	0.000

Table 9 portrays that all indicators of the scientific attitude of the experimental class before the treatment were in the average category. After the treatment, all indicators of student scientific attitude increased to high in the category. The increase occurred evenly in each indicator. As for the control class, the scores of all indicators showed that students' scientific attitude is in the average category, the same as the initial conditions of the experimental class. After treatment, there were no significant changes in all indicators of scientific attitude in the control class. The students' scientific attitude of control class was still average. The level of changes in students' scientific attitudes before and after treatment was low in the category. These findings proved that Pancasila and Civic Education teaching materials with the TEE pattern effectively develop students' scientific attitudes.

As for the data from the analysis in Table 10, Pancasila and Civic Education teaching materials with the TEE pattern effectively improved students' scientific attitudes. The effectiveness of the developed teaching materials was reflected in the t-test value, which was lower than the sig value. 0.05. Based on these data, it is clear that Pancasila and Civic Education teaching materials with a TEE pattern are effective in improving students' scientific attitudes. The effectiveness of teaching materials with the TEE pattern in improving students' scientific attitudes cannot be separated from the activities in the teaching materials, tasks, explanations, and evaluations. These three activities provide opportunities for students to develop their scientific attitudes. The task section, for example, with the problems given, knocks students' curiosity and requires them to do investigations to answer each problem. With tasks in

teaching materials and guidance from lecturers, students will try to find and develop solutions or answers to each problem. According to research findings from Vishnumolakala et al. (2017), the process of finding solutions and guidance provided by lecturers effectively increases students' scientific attitudes. On the other hand, in general, the effect of all activities in problem-solving is an increase in students' scientific attitudes (Gurses et al. in Wahyudiati, 2019). This opinion is in line with the results of research conducted by Wahyudiati et al. (2020) that students' scientific attitudes can be improved through problem-solving activities.

Through explanation and evaluation sections in teaching materials, they have a significant effect on increasing students' scientific attitudes. It is because, in explanation activities, students actively construct their knowledge by reading and understanding the argumentative narratives in textbooks. This intense activity will improve students' hard and soft skills, including their scientific attitude (Rossi et al., 2021). In addition, this constructive learning process causes students' understanding of the material to increase their scientific attitude (Sari, Sudargo, & Priyandoko, 2018). Corresponding to the explanation section, the evaluation activities in the developed teaching materials provide space for students to think, search, match, and correct each answer. These activities will automatically train and develop their scientific attitude. So, the effectiveness of the evaluation section in teaching materials on students' scientific attitudes is the impact of these processes. The findings of this study are in line with the findings of Gede (2018) and Suastra & Ristiati (2019), which explain that evaluation has a significant effect on scientific attitudes.

Conclusion

From the findings and discussion above, it can be concluded that teaching materials designed using the TEE pattern effectively improve students' critical thinking skills and scientific attitudes. The effectiveness of these teaching materials in improving students' critical thinking skills and scientific attitudes is the impact of the activities in the three parts of the teaching materials, understanding of the material, and the technical completion of the parts that must be done in stages and thoroughly. All of these conditions could occur because the design of teaching materials requires students to use their higher-order thinking skills. The maximum functionalization of HOT features in learning influences the formation of critical thinking and scientific attitudes (Peter, 2012). Based on the findings of this study, it is suggested that lecturers use teaching materials with a TEE pattern in their learning to improve their students' critical thinking skills and scientific attitudes.

Suggestion

Further research is needed to determine the effectiveness of teaching materials using the TEE pattern in other subjects, especially in natural sciences which has different characteristics from social sciences. Through expanded research it will be known how the ability of teaching materials with the TEE pattern in improving students' critical thinking skills and scientific attitudes. In addition, it is necessary to conduct research to determine the effect of the teaching materials on other competencies. This teaching material model is also important to be developed and tested at the primary and secondary education levels.

Limitation

This study just examines the effect of teaching materials on students' critical thinking skills and scientific attitudes in one course. Additionally, this research focused solely on a small class; therefore, studies must be conducted on a larger class to evaluate its effectiveness accurately.

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