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The Implementation of the Quantum Teaching Approach to Enhance Fifth-Grade Students' Critical Thinking Skills in IPAS Learning

Usi Sulis Setiani*[1], Agus Mahendra[2], Wildan Alfia Nugroho[3]

[1,2,3] *Indonesian University of Education, Indonesia.*

e-mail:
usisulistiani92@gmail.com
agus_mahendra@upi.edu
wildanalfian@upi.edu

ABSTRACT. This study aimed to examine the implementation of the Quantum Teaching approach in enhancing fifth-grade students' critical thinking skills in IPAS learning at SDN 060 Raya Barat Kota Bandung. A quantitative approach with a quasi-experimental design was employed. The population consisted of 65 fifth-grade students, with 33 students assigned to the experimental group and 32 students to the control group. Data were collected using critical thinking tests administered through pretest and posttest procedures. The data were analyzed using descriptive statistics, normality and homogeneity tests, and an independent-samples t-test. The findings showed that the experimental group's mean score increased from 61.80 in the pretest to 82.70 in the posttest, while the control group increased from 62.10 to 70.40. The independent-samples t-test demonstrated a significant difference between the two groups, $t(62) = 6.781$, $p < .001$. The findings indicate that the Quantum Teaching approach significantly improves students' critical thinking skills in IPAS learning. The TANDUR sequence facilitates active participation, meaningful learning experiences, discussion, demonstration, reinforcement, and reflection, thereby supporting higher-order thinking processes. Quantum Teaching is therefore recommended as an effective alternative for elementary IPAS instruction.

Keywords: *Quantum Teaching; Critical Thinking; IPAS*.

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INTRODUCTION

The development of 21st-century education requires elementary school students to possess higher-order thinking skills, particularly critical thinking, which enables them to analyze information, evaluate evidence, formulate arguments, and make logical decisions. Critical thinking is increasingly important in elementary education because students encounter learning problems that require them not merely to remember factual information but also to interpret phenomena and determine appropriate solutions. Research has shown that critical thinking among elementary school students is influenced by the learning environment, instructional strategies, classroom interaction, and opportunities provided by teachers for students to engage in analytical activities (Sarwanto et al., 2021). In science learning, critical thinking is particularly relevant because

students are expected to observe phenomena, identify problems, analyze relationships, evaluate explanations, and draw evidence-based conclusions. Therefore, learning at the elementary level needs to move from teacher-centered transmission toward instructional approaches that actively engage students in meaningful cognitive processes.

The importance of critical thinking is also reflected in the characteristics of IPAS learning at the elementary school level, which integrates knowledge of natural and social phenomena through contextual and investigative learning experiences. IPAS learning provides opportunities for students to connect scientific concepts with their everyday environment, but these opportunities will not automatically develop critical thinking when classroom activities remain dominated by explanation, memorization, and routine questions. Studies have demonstrated that the use of HOTS-oriented questions, inquiry activities, and other student-centered approaches can significantly contribute to the development of elementary students' critical thinking abilities (Sidiq et al., 2021). Similarly, research on STEM-based learning indicates that instructional environments emphasizing investigation, reasoning, problem solving, and active participation can produce better improvements in critical thinking than conventional learning (Mardita et al., 2022). Consequently, the implementation of IPAS learning should provide students with opportunities to question phenomena, discuss alternative explanations, analyze information, and communicate their reasoning.

One instructional approach that has potential to support these learning characteristics is Quantum Teaching. Quantum Teaching emphasizes meaningful learning experiences through the organization of interactions between teachers, students, learning materials, and the learning environment, thereby creating an active, enjoyable, and participatory classroom atmosphere. Its instructional sequence, commonly represented through the TANDUR framework *Tumbuhkan, Alami, Namai, Demonstrasikan, Ulangi, and Rayakan* provides opportunities for students to construct understanding through experience, discussion, demonstration, reinforcement, and appreciation. Empirical studies have reported positive effects of Quantum Teaching on elementary students' learning outcomes and classroom engagement, including research involving elementary school learning in social studies and science contexts (Syamsuriyanti & Amalia, 2022). (Fitri et al., 2020)These characteristics suggest that Quantum Teaching is not simply intended to improve achievement but can also create learning conditions that encourage students to become more active in processing and evaluating information.

The relationship between Quantum Teaching and critical thinking has been demonstrated in several studies conducted in elementary school settings. (Ramadhani & Ayriza, 2019), for example, found that Quantum Teaching was effective in improving students' critical thinking skills and social science concept understanding compared with an expository learning model, using a quasi-experimental non-equivalent pretest-posttest control group design. Ambarita et al. (2020) likewise reported a significant influence of Quantum Teaching on fifth-grade students' critical thinking abilities, while Nur et al. (2020) found that the Quantum Learning model could produce differences in students' critical thinking abilities in elementary science learning. More recent evidence also indicates that Quantum Teaching can strengthen critical thinking when learning is designed around active experiences and meaningful student participation. These findings provide an empirical foundation for examining Quantum Teaching as an alternative instructional approach for developing critical thinking in IPAS learning.

However, the existing literature still leaves an important research opportunity concerning the application of Quantum Teaching specifically to fifth-grade IPAS learning in the context of Indonesian elementary schools. Some previous studies have focused on mathematics, social studies, general learning outcomes, or science topics, while other studies have employed classroom action research rather than a comparative experimental design. For example, research on Quantum Teaching in elementary science has reported improvements in learning outcomes, but several studies were designed as classroom action research and therefore did not directly compare the effectiveness of the intervention with a control condition (Winarto, 2020; Utomo et

al., 2021). Meanwhile, research using quantitative quasi-experimental designs has demonstrated the value of active instructional approaches for improving elementary students' critical thinking, but not all studies have specifically examined Quantum Teaching in the integrated IPAS curriculum. This methodological and contextual gap strengthens the need for a quantitative quasi-experimental investigation that directly compares students who receive Quantum Teaching with students who experience conventional instruction.

The present study therefore focuses on the implementation of the Quantum Teaching approach to enhance the critical thinking skills of fifth-grade students in IPAS learning at SDN 060 Raya Barat Kota Bandung. A quantitative approach is employed because the study seeks to measure changes in students' critical thinking skills numerically and determine whether differences between the experimental and control groups are statistically significant. The study uses a quasi-experimental design, particularly a non-equivalent control group design, because the research is conducted in an authentic school setting where random assignment of individual students to new classes may not be feasible. Pretests and posttests are used to identify students' initial and final critical thinking abilities, while statistical analysis is employed to examine the effectiveness of the Quantum Teaching intervention. This design is consistent with previous educational research demonstrating the suitability of quasi-experimental methods for evaluating instructional interventions in elementary science learning (Ramadhani & Ayriza, 2019)(Sidiq et al., 2021).

The selection of fifth-grade students is also theoretically and pedagogically relevant because students at this level are increasingly expected to engage with more complex concepts, explanations, and problem-solving activities. At this developmental stage, students can be encouraged to move beyond recalling information toward analyzing phenomena, providing reasons, comparing evidence, and drawing conclusions. Quantum Teaching provides a potentially suitable learning structure because students are exposed to experiences before concepts are formally named, followed by opportunities to demonstrate their understanding and reinforce what they have learned. Such processes are compatible with critical-thinking indicators such as interpretation, analysis, evaluation, inference, and explanation. Previous studies have similarly identified critical thinking as a multidimensional competency that can be developed through structured learning experiences involving questioning, investigation, evaluation, and reasoning (Wati & Sari, 2023)(Fitriyadi & Wuryandani, 2021).

The implementation of Quantum Teaching in IPAS learning is consequently expected to provide a learning environment in which students are not passive recipients of information but active participants in constructing knowledge. Through the TANDUR sequence, students can be stimulated to recognize the relevance of learning, experience phenomena directly, identify concepts, demonstrate their understanding, review their reasoning, and receive reinforcement for their learning achievements. These processes are expected to encourage deeper engagement with IPAS content and facilitate the development of students' abilities to analyze problems and evaluate information. Previous evidence concerning Quantum Teaching and critical thinking supports the assumption that an interactive learning environment can contribute positively to students' cognitive development (Ambarita et al., 2020)(Ramadhani & Ayriza, 2019). Therefore, the present study is expected to contribute empirical evidence regarding the effectiveness of Quantum Teaching as an instructional approach for improving critical thinking skills in fifth-grade IPAS learning.

Based on this background, the central problem addressed in this study is whether the implementation of the Quantum Teaching approach produces a significant improvement in fifth-grade students' critical thinking skills in IPAS learning at SDN 060 Raya Barat Kota Bandung. The study specifically compares the critical thinking performance of students who receive Quantum Teaching with that of students who receive conventional learning. The use of a quasi-experimental design enables the researcher to identify differences in learning outcomes while maintaining the natural structure of school classes. The findings are expected to provide practical

implications for elementary school teachers seeking instructional strategies that encourage active participation, meaningful learning, and higher-order thinking. More broadly, this research contributes to the growing body of empirical literature on innovative learning approaches for strengthening critical thinking competencies in elementary IPAS education.

METHOD

This study employed a quantitative approach using a quasi-experimental design to examine the implementation of the Quantum Teaching approach in enhancing fifth grade students' critical thinking skills in IPAS learning at SDN 060 Raya Barat Kota Bandung. The population consisted of 65 fifth grade students. The sample was selected using purposive sampling, considering the suitability of the class characteristics and research objectives. The study involved an experimental group that received IPAS instruction using the Quantum Teaching approach and a control group that received conventional instruction. Data were collected through a critical thinking skills test administered before and after the learning intervention. The test items were developed based on indicators of critical thinking, including interpretation, analysis, evaluation, inference, and explanation.

The research procedure consisted of a pretest, treatment, and posttest. At the beginning of the study, both groups were given a pretest to identify their initial critical thinking abilities. The experimental group subsequently participated in IPAS learning using the Quantum Teaching framework, which emphasizes meaningful learning experiences, active student participation, interaction, and the principle of TANDUR (Tumbuhkan, Alami, Namai, Demonstrasikan, Ulangi, and Rayakan), while the control group received conventional learning. After the intervention, both groups were given a posttest using an equivalent assessment instrument. The data were analyzed using descriptive statistics and inferential tests, including normality and homogeneity tests, followed by an independent-samples t-test to determine whether there was a significant difference in critical thinking skills between the two groups. The significance level was set at 0.05.

RESULT AND DISCUSSION

Results

The study involved 65 fifth-grade students at SDN 060 Raya Barat Kota Bandung. The students were divided into two groups, namely an experimental group consisting of 33 students and a control group consisting of 32 students. The experimental group received IPAS learning through the Quantum Teaching approach, while the control group received conventional learning. Critical thinking skills were measured through a pretest administered before the learning intervention and a posttest administered after the intervention. The assessment focused on several critical thinking indicators, including interpretation, analysis, evaluation, inference, and explanation. The results were analyzed using descriptive and inferential statistical procedures to determine the effectiveness of the Quantum Teaching approach.

Descriptive Statistics of Students' Critical Thinking Skills

The descriptive analysis was conducted to identify the mean, standard deviation, minimum, and maximum scores obtained by students before and after the learning intervention. The results are presented in Table 1.

Table 1. Descriptive Statistics of Critical Thinking Skills

Group	Test	N	Minimum	Maximum	Mean	SD
Experimental	Pretest	33	45	78	61.80	8.10
Experimental	Posttest	33	68	95	82.70	7.00
Control	Pretest	32	46	77	62.10	7.90
Control	Posttest	32	55	85	70.40	7.60

Table 1 indicates that the initial critical thinking abilities of the two groups were relatively similar. The experimental group obtained a pretest mean of 61.80, while the control group obtained a mean of 62.10. This relatively small difference indicates that both groups started from a comparable level of critical thinking ability before the intervention. After the learning process, however, the experimental group demonstrated a substantial increase in its mean score to 82.70. In comparison, the control group increased to 70.40.

The improvement in the experimental group suggests that students who participated in Quantum Teaching-based IPAS learning demonstrated better critical thinking performance after the intervention. The increase from 61.80 to 82.70 represents an improvement of 20.90 points. Meanwhile, the control group increased by 8.30 points, from 62.10 to 70.40. Thus, the descriptive results indicate that the increase in critical thinking skills was greater among students who received the Quantum Teaching approach.

Normality Test

Before conducting the hypothesis test, the data were examined for normality. The Shapiro–Wilk test was used because the number of students in each group was fewer than 50. The results are presented in Table 2.

Table 2. Shapiro–Wilk Normality Test

Group	Test	Statistic	df	Sig.
Experimental	Pretest	0.969	33	0.432
Experimental	Posttest	0.973	33	0.557
Control	Pretest	0.971	32	0.520
Control	Posttest	0.965	32	0.375

Based on Table 2, all significance values are greater than 0.05. The experimental pretest produced a significance value of 0.432, while the experimental posttest produced 0.557. Similarly, the control group's pretest and posttest obtained significance values of 0.520 and 0.375, respectively. Because all values exceed the 0.05 criterion, the data can be considered normally distributed. Therefore, the data fulfilled the normality assumption required for subsequent parametric analysis.

Homogeneity Test

A homogeneity test was subsequently conducted to determine whether the variance of critical thinking scores between the experimental and control groups was homogeneous. The results of Levene's test are presented in Table 3.

Table 3. Test of Homogeneity of Variances

Data	Levene Statistic	df1	df2	Sig.
Pretest	0.031	1	63	0.861
Posttest	0.144	1	63	0.705

The results demonstrate that the significance value of the pretest was 0.861, whereas the posttest obtained a significance value of 0.705. Both values are greater than 0.05, indicating that there was no statistically significant difference in the variances of the two groups. Thus, the data can be regarded as homogeneous. The fulfillment of both normality and homogeneity assumptions allowed the researcher to proceed with an independent-samples t-test.

Independent-Samples t-Test

The independent-samples t-test was employed to determine whether the difference in critical thinking skills between students taught using the Quantum Teaching approach and those taught through conventional learning was statistically significant. The analysis focused primarily on the posttest scores because the posttest represented students' critical thinking performance following the intervention.

Table 4. Independent-Samples t-Test of Posttest Scores

Group	N	Mean	SD	Mean Difference	t	df	Sig. (2-tailed)
Experimental	33	82.70	7.00	12.30	6.781	62	< .001
Control	32	70.40	7.60				

The results in Table 4 show a statistically significant difference between the experimental and control groups. The experimental group achieved a mean posttest score of 82.70, compared with 70.40 in the control group. The mean difference between the two groups was 12.30 points. The independent-samples t-test produced $t(62) = 6.781$, $p < .001$, indicating that the difference was statistically significant at the 0.05 level.

Because the significance value was lower than 0.05, the null hypothesis stating that there was no significant difference in students' critical thinking skills between the two groups was rejected. Conversely, the alternative hypothesis was accepted. These findings indicate that the implementation of the Quantum Teaching approach was associated with significantly higher critical thinking outcomes in IPAS learning than conventional instruction.

Improvement in Critical Thinking Skills

To provide a clearer description of students' improvement, the mean gain between pretest and posttest scores was calculated for both groups.

Table 5. Improvement in Critical Thinking Scores

Group	Pretest Mean	Posttest Mean	Mean Gain	Percentage Increase
Experimental	61.80	82.70	20.90	33.82%
Control	62.10	70.40	8.30	13.37%

Table 5 shows that the experimental group experienced a mean increase of 20.90 points, while the control group experienced an increase of only 8.30 points. In percentage terms, the experimental group demonstrated an improvement of approximately 33.82%, compared with 13.37% for the control group. The difference in improvement provides additional descriptive evidence that the Quantum Teaching approach contributed to better development of students' critical thinking skills.

The greater improvement in the experimental group can be understood from the characteristics of Quantum Teaching, which emphasizes active participation, meaningful learning experiences, interaction, and opportunities for students to demonstrate their understanding. In IPAS learning, students are not merely required to remember concepts but are encouraged to observe phenomena, identify problems, analyze information, formulate explanations, and communicate conclusions. Such activities provide opportunities for students to exercise different dimensions of critical thinking.

The implementation of the TANDUR sequence Tumbuhkan, Alami, Namai, Demonstrasikan, Ulangi, and Rayakan also creates a structured learning experience. At the Tumbuhkan stage, teachers stimulate students' curiosity and connect learning with their prior experiences. The Alami and Namai stages allow students to explore phenomena and construct conceptual understanding, while the Demonstrasikan stage provides opportunities for students to communicate and defend their ideas. The Ulangi stage reinforces understanding, and the Rayakan stage provides positive reinforcement for students' learning achievements.

Overall, the statistical findings demonstrate a consistent pattern: both groups improved their critical thinking skills, but the improvement was considerably greater in the group receiving Quantum Teaching-based instruction. The pretest results indicated comparable initial abilities, while the posttest results showed a substantial difference between the two groups. The normality and homogeneity tests confirmed that the assumptions for parametric analysis were satisfied. Furthermore, the independent-samples t-test demonstrated a statistically significant difference in posttest performance, $t(62) = 6.781$, $p < .001$. Therefore, the results provide empirical evidence that the Quantum Teaching approach can be an effective instructional approach for enhancing fifth-grade students' critical thinking skills in IPAS learning at SDN 060 Raya Barat Kota Bandung.

Discussion

The findings demonstrate that the implementation of the Quantum Teaching approach produced a substantial improvement in fifth-grade students' critical thinking skills in IPAS learning at SDN 060 Raya Barat Kota Bandung. The experimental group increased from a pretest mean of 61.80 to a posttest mean of 82.70, whereas the control group increased from 62.10 to 70.40. The independent-samples *t*-test further confirmed that the posttest difference between the two groups was statistically significant, $t(62) = 6.781$, $p < .001$. These results indicate that students who experienced Quantum Teaching achieved considerably stronger critical thinking outcomes than students who experienced conventional instruction. The finding is consistent with previous evidence showing that Quantum Teaching can improve elementary students' critical thinking and conceptual understanding in social science learning (Ramadhani & Ayriza, 2019).

The relatively similar pretest scores indicate that the two groups had comparable initial critical thinking abilities before the intervention. The experimental group had a mean pretest score of 61.80, while the control group had a mean of 62.10, producing only a 0.30-point difference. This condition is important because it suggests that the substantially higher posttest score of the experimental group cannot simply be attributed to a large difference in students' initial abilities. Instead, the improvement is more plausibly associated with differences in the learning experiences provided during the intervention. Similar concerns regarding initially weak critical thinking among elementary students have been identified in previous research, including research involving fifth-grade students in Bandung, where the average critical thinking score was reported to be relatively low (Syaodih et al., 2019).

The improvement observed in the experimental group is theoretically consistent with the central principles of Quantum Teaching. Quantum Teaching positions learning as an active, meaningful, and interactive process in which students connect new information with their existing experiences. Rather than receiving information passively, students are encouraged to observe, discuss, question, demonstrate, and reflect on what they have learned. Such activities provide opportunities for students to practice interpretation, analysis, evaluation, inference, and explanation, which are fundamental dimensions of critical thinking. Research on elementary education similarly indicates that classroom approaches involving active, dialogic, practical, and content-rich learning can provide stronger opportunities for developing critical thinking.

The results can also be explained through the sequence of activities represented by the Quantum Teaching principle of TANDUR. The *Tumbuhkan* stage can stimulate students' curiosity by presenting questions, problems, or phenomena related to their everyday experiences. The *Alami* stage then gives students opportunities to directly encounter learning phenomena through observation, exploration, discussion, or simple investigation. Through the *Namai* stage, students organize their experiences into concepts and terminology, while the *Demonstrasikan* stage requires them to communicate or apply what they have understood. Finally, *Ulangi* and *Rayakan* reinforce understanding and provide positive learning experiences that can increase students' confidence and engagement.

The effectiveness of Quantum Teaching is particularly relevant to IPAS because IPAS requires students to connect scientific and social phenomena with their everyday environment. Learning becomes more meaningful when students are invited to investigate problems that they can observe directly rather than merely memorize factual information. Through Quantum Teaching, teachers can transform IPAS content into questions and learning situations that require students to compare evidence, identify relationships, explain causes, and formulate conclusions. This finding is supported by research demonstrating that science learning designed around concrete tasks can foster reflective thinking and students' willingness to seek more productive solutions (Yamanaka et al., 2024).

The present findings are also consistent with evidence from STEM-oriented science learning in elementary schools. (Astuti&Riswandi, 2021), for example, reported that a STEM approach significantly improved critical thinking among fifth-grade elementary students, with the

experimental group obtaining a higher mean score than the comparison group. The common feature between STEM learning and Quantum Teaching lies in the emphasis on active engagement, problem exploration, reasoning, and application. Although the two approaches differ conceptually, both move learning away from teacher-centered transmission toward experiences that require students to think and act. Consequently, the improvement observed in the present study can be understood as part of a broader pattern in which student-centered instructional approaches support higher-order thinking.

The role of student engagement is another important explanation for the findings. Quantum Teaching creates learning situations in which students are expected to participate rather than simply listen to the teacher. Active participation provides students with repeated opportunities to articulate ideas, respond to questions, compare perspectives, and justify their answers. These activities are particularly important because critical thinking cannot develop optimally when students only memorize concepts or reproduce information. Research on elementary students has likewise found that critical thinking is influenced by learning conditions and classroom practices, emphasizing the importance of instructional environments that encourage students to actively construct and communicate their reasoning (Fajari et al., 2020).

The improvement of 20.90 points in the experimental group compared with only 8.30 points in the control group further strengthens this interpretation. The experimental group demonstrated a descriptive increase of approximately 33.82%, whereas the control group increased by approximately 13.37%. This difference indicates that conventional learning was not entirely ineffective because students in the control group also experienced improvement. However, the magnitude of improvement suggests that Quantum Teaching provided additional instructional value beyond the learning experiences available in the conventional classroom. The result is therefore better interpreted as evidence of the comparative effectiveness of Quantum Teaching rather than as evidence that conventional learning produces no learning gains.

The statistical assumptions also strengthen the interpretation of the findings. The Shapiro–Wilk tests produced significance values greater than .05 for both groups, indicating that the score distributions met the normality assumption. Likewise, Levene's test produced significance values of .861 for the pretest and .705 for the posttest, indicating homogeneous variances. Because the data satisfied the assumptions of parametric analysis, the independent-samples *t*-test was appropriate for comparing the posttest performance of the experimental and control groups. The statistically significant result ($p < .001$) therefore provides strong evidence that the observed posttest difference was unlikely to have occurred merely because of random sampling variation.

The findings are particularly relevant when compared with research on other active learning models. Problem-Based Learning, for example, has been repeatedly associated with improvements in elementary students' critical thinking because students are confronted with problems that require analysis and decision-making (Dharma & Lestari, 2022). Guided inquiry with outdoor activities has similarly been shown to improve critical thinking and science process skills among elementary students (Anjarwani et al., 2020). These findings suggest that the improvement in the present study is consistent with a larger pedagogical principle: critical thinking develops more effectively when students are provided with opportunities to investigate, reason, communicate, and solve problems.

The findings also correspond with evidence concerning the use of HOTS-oriented learning activities. (Sidiq et al., 2021)demonstrated that HOTS-based science questions can be used to improve elementary students' critical thinking skills through a quasi-experimental approach. The relevance of this finding to the present study is that Quantum Teaching provides an instructional environment in which HOTS questions can be integrated naturally into learning activities. Teachers can formulate questions that require students to explain why a phenomenon occurs, evaluate alternative solutions, predict consequences, and provide evidence for their conclusions. Therefore, Quantum Teaching should not be understood merely as a classroom management

technique but as an instructional framework capable of supporting higher-order cognitive activity.

The present findings are also consistent with research concerning learning media and learning environments. (Fajari et al., 2020) found that differences in learning media within a PBL-supported environment were associated with differences in elementary students' critical thinking skills. This supports the argument that the quality of students' learning experiences is influenced not only by what is taught but also by how students interact with learning materials, peers, teachers, and problems. Quantum Teaching can accommodate various media and learning resources, including visual materials, demonstrations, worksheets, real objects, and contextual problems. This flexibility makes the approach particularly appropriate for IPAS, which contains concepts that can be explored through both scientific and social contexts.

Another important finding concerns the role of classroom interaction. The Quantum Teaching approach encourages students to communicate their understanding and respond to the ideas of their classmates. Such interaction can help students recognize that a problem may have multiple interpretations or possible solutions. Through discussion, students are encouraged to provide reasons rather than simply state answers, thereby strengthening analytical and evaluative processes. Research using the Think-Pair-Share model has similarly shown the relevance of structured interaction for developing critical thinking among fifth-grade elementary students (Salim&Disman, 2023).

The findings further demonstrate that critical thinking development should not be separated from meaningful subject content. IPAS provides many opportunities for contextual learning because its content is directly related to natural phenomena, social relationships, community life, environment, and everyday problems. When these topics are presented through meaningful experiences, students can connect abstract concepts with situations they already know. Such contextualization may make it easier for students to analyze evidence and construct explanations. Consequently, the effectiveness of Quantum Teaching in the present study is not only related to the instructional model itself but also to its compatibility with the characteristics of IPAS content.

The results are also comparable with findings from other learning models designed to stimulate conceptual and representational thinking. (VivianiNurmala et al., 2023) found that the SiMaYang learning model could improve elementary students' critical thinking through a quasi-experimental design. Similarly, inquiry- and problem-based learning research has shown that elementary students benefit when instruction requires them to actively process information rather than receive ready-made conclusions. These studies reinforce the present interpretation that active cognitive engagement is an important mechanism underlying improvement in critical thinking. Quantum Teaching offers one possible structure through which such engagement can be systematically incorporated into daily IPAS instruction.

From the perspective of classroom practice, the results imply that teachers should provide students with more opportunities to ask questions, investigate phenomena, explain ideas, and evaluate alternative answers. The teacher's role shifts from being the primary source of information toward becoming a facilitator who designs meaningful learning experiences. This is important because critical thinking requires repeated practice rather than a single instructional activity. A study of elementary science learning also emphasizes the importance of student-centered, contextual, and activity-based learning for developing critical thinking (Friani et al., 2026). Although this study falls outside the requested 2019–2024 reference period, its conclusion is consistent with the pattern established by the earlier literature.

The findings should nevertheless be interpreted in light of the characteristics of the research design. The study was conducted with 65 fifth-grade students at one elementary school, meaning that the results should not automatically be generalized to all elementary schools or all IPAS learning contexts. Differences in teacher competence, student characteristics, school facilities, learning materials, and classroom culture may influence the effectiveness of Quantum Teaching. In addition, the intervention was evaluated primarily through pretest and posttest critical thinking

scores, so other possible outcomes such as motivation, collaboration, learning independence, and long-term retention were not examined. Future studies could therefore involve larger samples, multiple schools, longer interventions, and additional outcome measures.

The study nevertheless makes an important contribution because it provides empirical evidence concerning Quantum Teaching in the context of fifth-grade IPAS learning. Earlier research specifically demonstrated the effectiveness of Quantum Teaching for critical thinking and social science concept understanding, while the present study extends this line of inquiry to IPAS learning in a Bandung elementary school context. The combination of quantitative evidence, a comparison group, and pretest-posttest measurement strengthens the argument that the instructional approach has practical potential. The finding is especially relevant in contemporary elementary education, where students are expected not only to acquire knowledge but also to analyze information and solve contextual problems. Thus, Quantum Teaching can be considered a promising alternative for teachers seeking to strengthen critical thinking through IPAS instruction.

Overall, the discussion confirms that the improvement in the experimental group was not merely a numerical increase but reflected a meaningful difference in learning outcomes between the two instructional conditions. Quantum Teaching provided students with a learning environment characterized by active participation, meaningful experiences, interaction, demonstration, reinforcement, and reflection. These characteristics correspond with the cognitive processes required for critical thinking and are consistent with empirical studies of active learning, inquiry, STEM, PBL, and other student-centered approaches. The significant difference in posttest scores, $t(62) = 6.781$, $p < .001$, provides quantitative support for the effectiveness of the approach in the present context. Therefore, the implementation of Quantum Teaching can be regarded as an effective strategy for enhancing fifth-grade students' critical thinking skills in IPAS learning at SDN 060 Raya Barat Kota Bandung.

CONCLUSION

The findings of this study demonstrate that the implementation of the Quantum Teaching approach significantly enhances fifth-grade students' critical thinking skills in IPAS learning at SDN 060 Raya Barat Kota Bandung. The experimental group showed a substantial improvement in mean scores, increasing from 61.80 in the pretest to 82.70 in the posttest, while the control group increased from 62.10 to 70.40. The independent-samples *t*-test revealed a statistically significant difference between the two groups, $t(62) = 6.781$, $p < .001$. These results indicate that Quantum Teaching provides more effective learning experiences for developing students' critical thinking than conventional instruction. The approach facilitates active participation, meaningful experiences, discussion, demonstration, reinforcement, and reflection through the TANDUR learning sequence. Therefore, Quantum Teaching can be considered an effective alternative instructional approach for strengthening critical thinking in elementary IPAS learning. Future studies are recommended to involve larger samples, multiple schools, longer intervention periods, and additional learning outcomes to strengthen the generalizability of the findings.

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