

Research Article

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Utilizing Team-Based Project Research in Improving Scientific Thinking Skills Among Social Studies Students in Higher Education

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Abstract

Background/purpose. Scientific thinking is a critical competency for navigating the complexities of the global era, requiring the application of scientific methods to understand, analyze, and evaluate diverse phenomena and problems. This study examines the effectiveness of Team-Based Project Research (TBPR) in enhancing scientific thinking skills among students of the Social Studies Education program at the State University of Surabaya.

Materials/methods. A quantitative time-series experimental design was employed. Data were collected through questionnaires and analyzed using t-tests and ANOVA to test the hypotheses.

Results. The findings indicate that: (1) TBPR provides a systematic conceptual framework that supports pedagogical objectives through a structured sequence of research phases, ranging from problem identification to data analysis and reflection; (2) the implementation of TBPR significantly enhances students' scientific thinking skills in higher education; and (3) TBPR functions as an effective instructional model that promotes active knowledge construction, collaborative learning, and the development of higher-order scientific reasoning.

Conclusion. These results suggest that higher education institutions should adopt and further refine TBPR to strengthen students' scientific thinking abilities and collaborative research competencies.

1. Introduction

In the digital era, characterized by an abundance of information, the ability to think scientifically has become a critical competency for social studies students. Such competence enables them to critically evaluate evidence and construct coherent arguments (Hurley & Taiwo, 2019), as well as to demonstrate essential scientific reasoning skills (Krell, et al., 2020). Developing scientific analysis skills is paramount for preparing students to face future challenges (Agustina, Putra, & Listiawati, 2022; AlJaafil & Sahin, 2019; Aspland et al., 2020; Conole & Dyke, 2004; Dwyer, Hogan, & Stewart, 2014; Sieberer-Nagler, 2015; Srisawad & Chaleoykitti, 2019). These demands necessitate a transformation in learning methodologies that foster deeper engagement with knowledge and promote adaptive problem-solving.

From an academic standpoint, educational practices should position educators as facilitators of knowledge who design environments that actively involve students in the learning process (Goodyear & Dudley, 2015). Responding to these dynamics, this study seeks to improve the quality of learning in alignment with current educational needs. Specifically, three urgencies underlie this research. First, the study introduces the conceptual model of Team-Based Project Research (TBPR) as a means to foster scientific thinking skills. Second, it provides a comparative analysis of students' scientific thinking skills before and after the implementation of TBPR. Third, it examines the relationship between TBPR and the development of scientific thinking skills. Grounded in a constructivist perspective, this study views students as active agents in constructing knowledge through collaboration and scientific inquiry. Consequently, the investigation of TBPR implementation in enhancing scientific thinking skills offers an essential contribution to the discourse on education in the digital era.

Empirical evidence underscores the effectiveness of TBPR in cultivating scientific thinking across diverse educational contexts. This approach integrates collaborative learning with scientific inquiry, encouraging students to engage with authentic problems while constructing a deep conceptual understanding. Team-based collaboration provides opportunities for learners to construct arguments, evaluate evidence, and derive conclusions based on data. Gordon et al (2024) demonstrated that TBPR significantly enhances students' critical and scientific thinking compared to conventional instructional methods. Students engaged in team-based research projects demonstrated notable improvements in applying scientific methods, developing argumentative reasoning, and fostering metacognitive reflection (Yüksel, 2025). Furthermore, TBPR strengthens both learning motivation and cognitive engagement, which serve as essential foundations for the development of scientific thinking (García-Carmona, 2023). Taken together, these findings highlight TBPR as a pedagogically relevant strategy for cultivating scientific reasoning, particularly in preparing students to navigate the complexities of the digital era.

This study is grounded in the argument that scientific thinking skills are best developed through project-based learning processes, particularly when collaboration and higher-order thinking are emphasized, as these serve as key determinants in fostering scientific reasoning. TBPR model, implemented through off-campus activities, strengthens research competencies by engaging students in teamwork, time management, and professional networking (Samane et al., 2025), while also cultivating self-efficacy as they independently solve problems and overcome challenges (Yada & Savolainen, 2017). By situating learning within authentic contexts, TBPR not only advances students' capacity to construct knowledge but also provides a pedagogically relevant strategy for enhancing their scientific competencies. Thus, this study contributes both theoretically and practically to the advancement of project-based learning in higher education, addresses gaps in the literature regarding off-campus TBPR models for adult learners, and offers recommendations for improving teaching and learning quality in Indonesia.

2. Literature Review

2.1. *The Importance of Scientific Thinking in Higher Education*

Scientific thinking is a critical competency for higher education students, particularly in preparing them to succeed in the global era. This is because scientific thinking represents a form of complex reasoning that requires students to critically and analytically solve problems (Hyytinen et al., 2014). As a core academic skill, it equips students to understand, analyze, and evaluate phenomena through systematic scientific methods (Kuhn et al., 2008; Murtonen & Salmento, 2019). Evidence shows that students with strong scientific thinking skills are more competitive in various fields, as these skills enable adaptability to technological change, career readiness, and meaningful contributions to research and innovation (Maksum, Widiana, & Marini, 2021; Turiman, et al., 2012; Widana, 2017; Zolotoy, Sullivan, & Chen, 2019). Furthermore, scientific thinking empowers students to respond to global challenges with evidence-based arguments, supporting both personal growth and societal progress (Duruk, Akgün, Doğan, & Gülsuyu, 2016; Villena-Izurieta et al., 2024). Therefore, cultivating this competency in higher education is essential not only for academic excellence but also for building a society capable of solving real-world problems.

2.2. *The Scientific Thinking Process*

Scientific thinking can be defined as the ability to understand, analyze, and evaluate various phenomena or problems in order to construct clear, evidence-based arguments and propose appropriate solutions (Muhaimin et al., 2021). This process is systematic, rational, and organized, beginning with observation, followed by hypothesis formation, experimentation, critical evaluation, and the communication of results. Observation serves as the foundation, allowing individuals to identify and study conditions objectively as the initial stage of inquiry (Calabretta, Gemser, & Wijnberg, 2017). The data gathered through observation is then used to formulate hypotheses, which are tested through experiments and validated through data analysis. Critically evaluating the results ensures that conclusions are scientifically reliable and based on valid, trusted sources. Finally, these conclusions are communicated to relevant audiences, either through presentations in scientific forums or publications (Johansson-Sköldberg, Woodilla, & Çetinkaya, 2013). Through this cycle, students not only construct scientific knowledge but also develop the ability to communicate findings effectively.

The importance of this process lies in its ability to ensure that knowledge is generated through valid evidence and rigorous methods (Al-Haqan, Smith, Bader, & Bates, 2021; Hemans et al., 2023; Trumbull, Bonney, Bascom, & Cabral, 2000). Scientific thinking is not only essential in research but also in daily life, as it supports rational decision-making and the critical evaluation of information (Fahmi, Yuwanita, & Faiza, 2021). By engaging in logical and organized reasoning, individuals are better equipped to analyze complex situations, avoid misinformation, and make informed decisions based on facts (Mahendra et al., 2022). Moreover, scientific thinking enhances interpersonal interaction by fostering the ability to present arguments logically and communicate ideas clearly (Utami, Aisyah, & Affifah, 2022). Thus, these skills remain relevant not only in academic and scientific contexts but also in everyday decision-making and professional development.

Despite its importance, scientific thinking skills must be intentionally cultivated, particularly in higher education, where students often demonstrate limited research abilities (Abdullah, Alrige, & Bitar, 2024). Although research is a central component of academic learning and human resource development, many students face challenges due to insufficient resources, low motivation, inadequate research training, and overly theoretical classroom environments (Muhlisin, Susilo, Amin, & Rohman, 2016). To address these barriers, higher education institutions must provide adequate infrastructure such as libraries, laboratories, and access to research tools, as well as strengthen lecturer guidance to motivate students' active participation in research. Research-based learning

activities, especially group projects, offer students authentic experiences in designing and conducting investigations, receiving feedback, and developing essential competencies. Such collaborative projects not only foster scientific thinking but also prepare students to face real-world challenges by providing practical research experience (Putra & Amalia, 2020).

2.3. The Role of Team-Based Research Projects in Developing Scientific Thinking

Team-based research projects represent an effective learning strategy for fostering scientific thinking in higher education. When students engage in research collaboratively, learning becomes not only more engaging but also more meaningful, as each team is responsible for a unique project that encourages cooperation and problem-solving. These projects may be conducted both inside and outside the classroom, with off-campus activities offering students authentic experiences in facing real-world problems relevant to their disciplines. Such experiences help bridge the gap between theory and practice, enabling students to apply classroom knowledge in real contexts while simultaneously developing practical competencies (Langmann, 2021; Rizaq & Sarmini, 2021).

Team-based project research further strengthens students' research capacities by equipping them with essential skills such as experiment design, data collection and analysis, and evaluation of findings (Robiyansah, Mudjito, & Murtadlo, 2020). Collaborative teamwork within these projects nurtures critical thinking, fosters mutual learning, and enhances problem-solving. In addition, projects situated outside the classroom frequently expose students to industry or community engagement, creating opportunities for professional networking and building communication skills that can be integrated into their academic and professional portfolios. Learning organized in groups, therefore, not only enriches academic understanding but also supports students' holistic development (Istiningsih et al., 2024).

Equally important, the use of the environment as a learning resource deepens the student research experience. Group-based projects that investigate real conditions in the surrounding community provide students with relevant and meaningful learning opportunities (Wahjusaputri & Nastiti, 2022). However, these research contexts must align with students' fields of specialization to ensure both relevance and engagement (Maksum et al., 2021). Alternative environments for learning include open spaces, laboratories, and specialized facilities, as well as community-based settings. With advancements in technology, digital platforms and virtual environments also serve as valuable research spaces, expanding the possibilities for learning (Armenia et al., 2019). Through such diverse environments, students gain broader experiences, strengthen the connection between theory and practice, and develop transferable skills that prepare them for future challenges.

2.4. The Benefit of Team-Based Research Projects in Higher Education

Expanding the surrounding environment as a learning resource through team-based research projects offers significant benefits for enhancing students' academic and professional competencies. Participation in such projects enables students to acquire essential research skills, including the ability to formulate hypotheses, design research instruments, collect data, and compile comprehensive reports (Belecina & Jose M Ocampo, 2018). In addition, research projects strengthen students' data analysis skills by training them to apply statistical tools and appropriate analytical techniques. Another crucial outcome is the development of scientific communication skills, as students learn to present their findings clearly and systematically through reports, presentations, and publications. These experiences also cultivate higher-order thinking skills—critical, creative, and problem-solving abilities—that allow students to analyze existing conditions critically and generate innovative solutions (Turiman et al., 2012). From a professional perspective, research projects further equip students with transferable skills such as time management, project organization, teamwork, and adaptability, making them valuable experiences for both academic advancement and career readiness.

Off-campus, TBPR provides an especially effective platform for deepening students' scientific understanding. Empirical evidence suggests that students' direct engagement in such projects bridges the gap between theoretical knowledge and real-world applications, fostering a more meaningful comprehension of academic concepts. These projects also serve as a training ground for complex skills, including critical reasoning, problem-solving, and technical proficiencies such as data analysis and digital literacy. In the context of social studies, TBPR enhances students' ability to connect theoretical frameworks with practical realities, thereby enriching their understanding of dynamic social phenomena (Utami et al., 2022). Despite the growing body of research on TBPR, most prior applications have been concentrated in STEM disciplines or in off-campus, community-based initiatives focused on teamwork, problem-solving, and the creation of tangible outputs such as prototypes or service programs (Hite et al., 2020; Mustafa et al., 2025). While these studies highlight TBPR's potential to foster collaboration and applied learning, they offer limited insights into its effectiveness in cultivating scientific thinking as a cognitive process. Within social studies education, research remains scarce, and there is little empirical evidence on how the structured phases of TBPR—from problem identification to reflection can be effectively adapted to meet the unique demands of the discipline. Furthermore, existing evaluations tend to emphasize project outcomes rather than the systematic development of students' scientific reasoning (Al-Kamzari & Alias, 2025; Ghazali, Ashari, Hardman, & Zabit, 2025). Addressing this gap, the present study investigates the implementation of TBPR in higher education social studies contexts, with particular attention to its role in strengthening students' scientific thinking skills.

The purpose of this study is to advance understanding of TBPR's potential in off-campus learning environments by examining its effectiveness in fostering scientific thinking among social studies students. As future agents of change, university students must develop strong scientific reasoning abilities to address complex real-world challenges (Shanta, 2022). TBPR offers a pedagogical framework that integrates diverse learning activities designed to promote 21st-century competencies (Martinez, 2022). Accordingly, this study seeks to (1) design an off-campus TBPR model suitable for social studies higher education and (2) evaluate its impact on the development of students' scientific thinking. By doing so, this research aims to contribute new perspectives on effective strategies for cultivating scientific reasoning as a core competency in higher education.

3. Methodology

This study employed a quantitative design using a time-series experimental method consisting of three stages: pre-measurement, the TBPR learning process, and post-measurement. The implementation of TBPR lasted four months, comprising three months of classroom activities focused on project research planning, one week of fieldwork in Sumenep Regency, Madura, and one month dedicated to writing research reports and scientific articles. The participants were 74 students from the Social Studies Education Program at the State University of Surabaya, selected through purposive sampling (Creswell, 2014). The inclusion criteria required fourth-semester students who were enrolled in extracurricular courses involving research-based project work, as they had completed foundational courses in research methodology and social studies theory and were thus adequately prepared to engage in TBPR activities. Purposive sampling was considered appropriate to ensure participants' alignment with TBPR objectives, though it carries the potential risk of selection bias by limiting representation across other academic levels or programs. To mitigate this limitation, the selected cohort was consistent with the typical academic trajectory of Social Studies Education students. Future research is encouraged to employ random sampling across multiple cohorts and institutions to enhance the generalizability of findings.

Data were collected using a structured questionnaire designed to assess students' scientific thinking skills, consisting of multiple items developed based on established indicators of scientific reasoning such as problem identification, hypothesis formulation, data interpretation, and conclusion

drawing (Ross, 2017). The items were presented on a Likert scale, enabling respondents to indicate the extent of their agreement or disagreement with each statement, and the questionnaire was administered both before and after the implementation of TBPR to measure changes in students' scientific thinking skills. Prior to administration, the instrument underwent validation through expert judgment in social studies education and was tested for reliability using Cronbach's alpha to ensure internal consistency. The indicators of scientific thinking skills applied in the instrument were adapted from educational and psychological frameworks which encompassed four dimensions: inquiry (identifying problems, searching for reference sources, formulating hypotheses, and planning research), analysis (selecting research methods, developing instruments, collecting and processing data), inference (interpreting data, presenting findings, and summarizing results), and argumentation (connecting research results to theoretical concepts and comparing findings with previous studies) (Jensen et al., 2023).

Table 1. Test Instrument Scientific Thinking Skills

Indicators		Question Item	Sig. (2-tailed)
Inquiry	1.	Searches and cites credible sources	0,024
	2.	Formulates clear, researchable problems	0,025
	3.	Proposes logical hypotheses	0,071
	4.	Outlines step-by-step research plans	0,003
Analysis	5.	Chooses appropriate research methods	0,083
	6.	Develops valid instruments	0,000
	7.	Collects data systematically	0,006
	8.	Processes data with suitable techniques	0,002
Inference	9.	Interprets patterns in results	0,010
	10.	Presents findings coherently	0,013
	11.	Draws evidence-based conclusions	0,001
Argumentation	12.	Connects findings to theories/concepts	0,002
	13.	Compares results with prior studies	0,018
	14.	Justifies claims with evidence	0,012

Table 1 demonstrates that the instrument test, conducted using the product-moment correlation technique, confirms the validity of the 14 questions. This is evidenced that each Sig. value (2-tailed) $< \alpha$ 0,05. Hence, this questionnaire instrument can be used to evaluate the students scientific thinking skills. Following that, the essay question instrument received another test to evaluate the consistency of the responses to the questionnaire they responded. See the reliability test results in Table 2 for more details.

Table 2. Reliability Test of Instruments

Cronbach's Alpha	N of Items
0,746	14

The pre-measurement and post-measurement data are analyzed through parametric statistics, where the data must be normally distributed and homogeneous. The research hypothesis was tested

using a t-test with a paired sample and ANOVA tests. The decision rule is if Sig. (2-tailed) < 0.05, then H_a is accepted, and H_o is rejected. On the other hand, if Sig. (2-tailed) > 0.05, then H_a is rejected, and H_o is accepted. The result of this research is analyzed from a constructivist perspective that explain learning is an active, contextualized process in which learners construct knowledge through interaction with their environment and collaboration with others (Zajda, 2021). In the context of TBPR, constructivism provides a foundation for understanding how students internalize values of religious moderation. Rather than being passively transmitted, these values are actively negotiated through classroom dialogue, reflective activities, and engagement with diverse cultural and religious perspectives. This alignment shows that TBPR is not only a pedagogical approach but also a constructivist practice where learners co-create meaning about tolerance, respect, and inclusivity in real educational settings.

4. Results

This research systematically optimizes higher education learning processes to enhance student experiences and foster meaningful learning outcomes. The study focuses on a research project-based learning (RPBL), also known as the TBPR design. RPBL/TBPR is a pedagogical framework that engages students in collaborative group projects to address specific research questions or problems. This methodology promotes learning through collaboration, independent inquiry, and hands-on experience. This methodology is guided by faculty, and the RPBL process unfolds in several key stages.

4.1. The Conceptual Model of Team-Based Project Research (TBPR) in Improving Scientific Thinking Skills

To systematically cultivate scientific thinking among students, particularly within the domain of social studies education, a structured learning model that emphasizes collaboration, inquiry, and real-world engagement is essential. The TBPR model provides a conceptual framework to achieve these pedagogical aims through a series of interconnected phases. By guiding students through authentic research experiences, TBPR fosters higher-order thinking skills, enabling learners to progress from problem identification to data analysis, interpretation, and reflection. Each stage of the model is deliberately designed to strengthen specific dimensions of scientific thinking, thereby ensuring that students not only acquire theoretical knowledge but also develop the ability to apply it in practical, research-oriented contexts. The following section elaborates on the core stages of the TBPR model and demonstrates how they contribute to the systematic enhancement of students' scientific thinking skills.

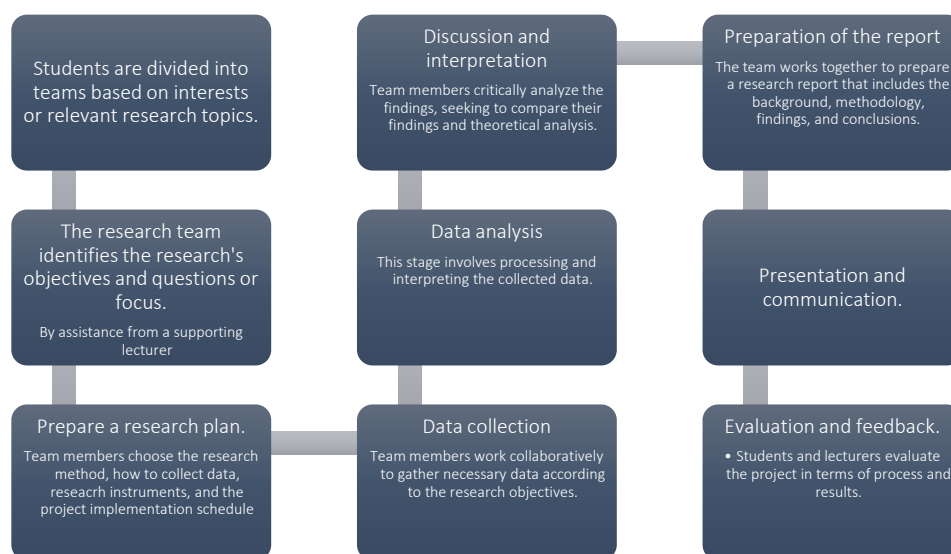


Figure 1. The Conceptual Model of Team-Based Project Research

Initially, students are organized into teams based on shared interests or relevant research topics, with each member assigned distinct roles within the project. In the subsequent stage, under the guidance of a supporting lecturer, each team identifies the research objectives and formulates the specific research questions. This stage involves complex thinking processes, as students analyze observations and raise critical questions to define the focus of their study. The third stage is research planning, where teams outline all aspects of the project, including the research methodology, data collection procedures, instruments or tools, and the project timeline. In the fourth stage, students collaboratively collect data, gaining hands-on experience in real research environments. Depending on the nature of the project, this phase may involve observation, interviews, experiments, or literature analysis, effectively turning the research setting into an active learning resource.

In the fifth stage, teams conduct data analysis, processing and interpreting the collected information using appropriate tools such as statistical software. This stage requires practical application of analytical skills to ensure objective and reliable results. The sixth stage involves discussion and interpretation, in which students critically examine their findings, compare results with existing theories, and engage in problem-solving—key components of scientific reasoning. The seventh stage is the preparation of the research report, which includes the background, methodology, results, and conclusions. This phase develops students' academic writing skills while emphasizing adherence to scientific writing standards. The eighth stage focuses on presentation and communication, where teams share their findings with peers or a broader audience through oral presentations, posters, or alternative formats, reinforcing effective communication skills. In the ninth stage, evaluation and feedback are conducted, allowing students and lecturers to assess both the research process and outcomes, providing constructive insights for improvement. Finally, the reflection stage encourages students to consider their experiences, academic growth, and personal skill development throughout the project.

Each stage of the TBPR model represents a component of lifelong learning, fostering attitudes of curiosity, persistence, and continuous inquiry. By engaging in team-based research, students develop a range of competencies, including scientific thinking, teamwork, communication, critical analysis, and problem-solving. Moreover, this experiential approach allows students to apply theoretical knowledge in authentic contexts, often resulting in deeper and more meaningful learning experiences compared with conventional classroom instruction.

4.2. A Comparative Analysis of Students' Scientific Thinking Skills

To ensure that the parametric test assumptions were met, a normality test was conducted on the pre-test and post-test data using both the Kolmogorov–Smirnov (KS) and Shapiro–Wilk (SW) tests. Both tests are commonly used to evaluate the distribution of data, with KS being a more general test and SW recognized for its higher power in small to medium sample sizes (Chatzi & Doody, 2023). The results are presented in Table 3.

Table 3. Normality Test of Students' Scientific Thinking Skills

Test	Statistic	df	Sig. (p)	Interpretation
Kolmogorov–Smirnov	0.078	74	0.200	Normal
Shapiro–Wilk	0.981	74	0.324	Normal

Note. A *p*-value greater than 0.05 indicates that the data are normally distributed.

Based on Table 3, both the Kolmogorov–Smirnov and Shapiro–Wilk tests yield significance values greater than 0.05. This indicates that the data are normally distributed, fulfilling the assumption for subsequent parametric analysis. While both tests show consistent results, the interpretation in this

study primarily refers to the Shapiro–Wilk test due to its higher reliability in medium-sized samples. Since the normality assumption was satisfied, further analyses using t-tests and ANOVA were considered appropriate.

To ensure that the assumption of equal variance between groups was met, a homogeneity test was conducted using Levene's test on the pre-test and post-test scores of students' scientific thinking skills. The results showed that the significance value was greater than 0.05, indicating that the data met the assumption of homogeneity of variance. This finding strengthens the validity of the subsequent comparative analysis, as the improvement observed in students' scientific thinking skills after participating in TBPR is not influenced by unequal variances across the groups (Indarti, Mardiyana, & Pramudya, 2018).

Table 4. Homogeneity Test of Students' Scientific Thinking Skills

(Source: processed by researchers, 2023)

Levene Statistic	df1	df2	Sig.	Decision
1.842	1	72	0.179	Homogeneous

The homogeneity of variances was tested using Levene's Test. The result showed a significance value of 0.179, which is greater than 0.05 (Zhou, Zhu, & Wong, 2023). This indicates that the data variances between the pre-test and post-test groups are equal, meaning the assumption of homogeneity was met (Emerson, 2022). Therefore, further statistical analysis using ANOVA and paired sample t-tests was considered appropriate.

It is important to note that the ability to think scientifically is a skill that can continue to develop throughout life. Therefore, higher education and research experience can help students improve their scientific thinking skills. In addition, an active, research-oriented approach to learning can facilitate the development of these skills more effectively. This research is conducted to develop students' scientific thinking skills. It first describes the initial scientific thinking skills before learning is carried out with team-based project research. For a clearer picture of students' scientific thinking skills before and after participating in learning with a team-based project research design, you can pay attention to the following figure.

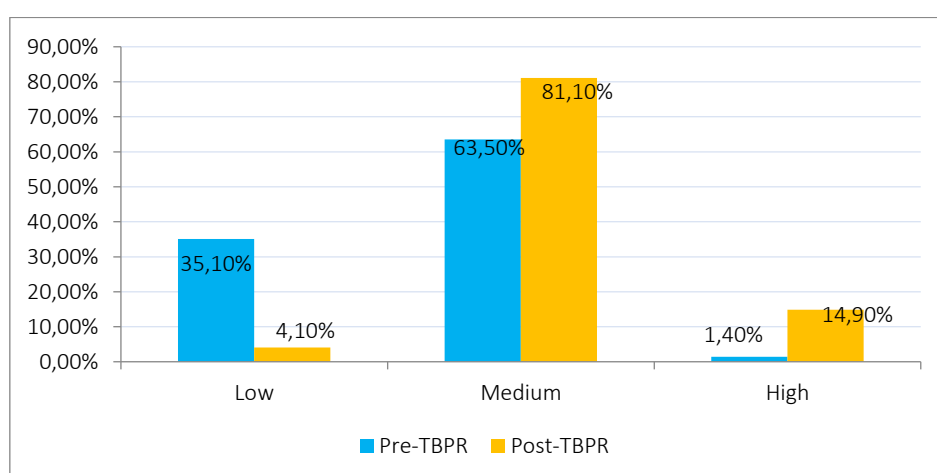


Figure 2. Comparison of Students' Scientific Thinking Skills

Figure 2 shows that the percentage of students categorized as having low scientific thinking abilities decreased significantly after participating in TBPR. In simple terms, this result indicates that Team-Based Project Research actively engages students, leading to an increase in improved scientific thinking skills. It can be seen from the medium category for scientific thinking skills, initially only

63.5% to 81.1% after participating in learning with team-based project research. Likewise, initially, it was only 1.40% to 14.9% in the high scientific thinking ability category. Such conditions generally show that students' scientific thinking improves when learning is done with team-based project research. That means that all respondents in the implementation of this research typically experienced increased scientific thinking skills. To comprehensively understand the achievement of student's scientific thinking ability scores before and after learning team-based project research can be seen in the following table.

Table 5. Comparison of Students' Scientific Thinking Abilities

(Source: processed by researchers, 2023)

Information	Lowest Rate	Highest Score
Pre-Test	29,00	89,00
Post-Test	46,00	92,00

Based on Table 5 above, it can be described that the average score of students' scientific thinking ability before studying with Team-Based Project Research is 55.13, which then increases after studying with Team-Based Project Research to 71,90. The lowest score achieved by students is related to scientific thinking skills before participating in design learning Team Project Research is 29,0, and the highest score is 89,00. Furthermore, when learning was organized with a Design Team Project Research, the lowest score was 46,00, and the highest was 92,00. So, there is an increase in both the lowest and highest scores achieved. The test was carried out to determine the effect of TBPR on scientific thinking statistically. To provide a clearer overview of student achievement, the descriptive statistics of each indicator of scientific thinking skills were analyzed. The results include the mean, standard deviation, and variance values for the pre-test and post-test, as presented in Table 6.

Table 6. Descriptive Statistics of Students' Scientific Thinking Indicators Before and After TBPR

(Source: Processed research data, 2023)

Indicator	Pre-Test Mean (M)	Pre-Test SD	Pre-Test Variance	Post-Test Mean (M)	Post-Test SD	Post-Test Variance
Inquiry	1.60	0.50	0.25	2.05	0.61	0.37
Analysis	1.70	0.53	0.28	2.15	0.63	0.40
Inference	1.65	0.52	0.27	2.10	0.62	0.38
Argumentation	1.70	0.54	0.29	2.12	0.62	0.39
Overall	1.66	0.52	0.27	2.11	0.62	0.38

Table 6 shows the descriptive statistics for students' scientific thinking indicators before and after TBPR implementation. Across all indicators, there was a clear increase in the mean scores, with Inquiry rising from 1.60 to 2.05, Analysis from 1.70 to 2.15, Inference from 1.65 to 2.10, and Argumentation from 1.70 to 2.12. These shifts illustrate that TBPR helped students' progress from the lower-to-medium levels toward the higher category of scientific thinking. The standard deviations and variances also increased slightly across all indicators, indicating more diverse student performance after TBPR. This variation suggests that while most students improved, the degree of improvement varied among individuals, reflecting the active, collaborative, and inquiry-driven nature

of TBPR. Team-based project research was carried out with a t-test to obtain the results, as seen in the following table.

Table 7. “t” Test Result (Source: processed by researchers, 2023)

Information		Calc	Sign
Pair 1	Final Scientific Thinking Ability Class	10,33	0,00
	Early Scientific Thinking Ability Class		
Pair 2	Final Scientific Thinking Ability Class	9,29	0,0
	Early Scientific Thinking Ability Class		

Based on the results of the test carried out, as seen in the table above, the result was obtained that the significance value for the two pairs of data tested was $0.001 < 0.05$. That value means there is a significant difference between the score of scientific thinking ability before learning and designing the Team-Based Project Research and afterward. Therefore, it is stated that the design of Team-Based Project Research, which is used in learning, can develop students' scientific thinking skills positively and significantly.

4.3. The Relationship Between TBPR Model and Scientific Thinking Skills Improvement

Tests were also carried out using *one-way ANOVA*, as the results can be seen in the following table.

Table 8. Variance Homogeneity Test Results

(Source: processed by researchers, 2023)

Levene Statistic	D	D	Sig.
2,094	1	14	0,150

Table 8 above shows the results of the variance homogeneity test as a prerequisite for conducting ANOVA testing. From the results obtained, it is known that the variance of the data is stated to be the same because the significance value obtained is $0.150 > 0.05$. Therefore, the ANOVA test is valid or feasible for testing this relationship. The results of the ANOVA test can be seen in the following table.

Table 9. ANOVA Test Results

(Source: processed by researchers, 2023)

Information	Df	F	Sig.
Between Group	1	91,8	0,001
Within Group	14		
Total	14		

Based on the results of the analysis carried out, as seen in Table 9 above, it is described that the significance value obtained is $0.00 < 0.05$, meaning there is a difference between the two data groups. Therefore, it is clear that Team Base Project Research design is used in effective learning to develop students' scientific thinking skills in higher education. Apart from the results of the tests carried out,

it is also known that there are soft skills that are improved explicitly through learning through team-based project research. Beyond scientific thinking, TBPR also enhance several soft skills including communication skills, problem-solving skills, the ability to make decisions objectively, the ability to cooperate, the ability to lead or lead, and the ability to adapt to the surrounding environment.

The results of the ANOVA analysis confirmed that there was a statistically significant difference in after the implementation of TBPR. However, statistical significance alone does not fully capture the magnitude or practical importance of this improvement. To provide a more comprehensive interpretation, it is necessary to calculate the effect size. Effect size offers additional insight by quantifying the extent to which TBPR contributes to the variance. In this study, both eta squared (η^2) and Cohen's d were used to measure the strength of the effect. The results are presented in Table 10.

Table 10. Effect Size of ANOVA Test
(Source: processed by researchers, 2023)

Effect Size Metric	Value	Interpretation
Eta Squared (η^2)	0.868	Very large effect
Cohen's d	2.05	Very large effect

Although the ANOVA test indicated a statistically significant difference after implementing TBPR ($p < 0.05$), it is also important to measure the magnitude of this difference. The effect size analysis showed an eta squared (η^2) value of 0.868, which indicates a very large effect. This means that approximately 86.8% of the variance can be explained by the TBPR learning design. In addition, Cohen's d value of 2.05 also demonstrates a very large effect size, strengthening the evidence that TBPR has a substantial impact on improving students' scientific thinking skills in higher education (Emerson, 2022).

5. Discussion

TBPR is a learning design that emphasizes student collaboration through group research projects. This approach has significant potential to enhance students' scientific thinking skills, as it engages learners across multiple stages of the research process (Kuhn et al., 2008; Budiastuti, Hartono, Astuti, & Wahyuni, 2023). Empirical evidence indicates that TBPR positively and significantly improves students' scientific thinking competencies. By participating in TBPR, students gain practical experience in teamwork, a fundamental element of both learning and scientific research. Collaborative engagement encourages students to communicate effectively, share ideas, solve problems collectively, and develop essential interpersonal and professional skills (Hujjatusnaini, Corebima, Prawiro, & Gofur, 2022; Issa & Khataibeh, 2021; Wijayati, Sumarni, & Supanti, 2019). The ability to contribute meaningfully within a team is a crucial component of scientific thinking, as most research endeavors require coordinated efforts to achieve shared objectives.

Another key benefit of TBPR is its capacity to deepen students' understanding of research methods by involving them directly in the research process rather than limiting instruction to theoretical explanations. Students engaged in TBPR acquire hands-on experience with data collection, data analysis, and decision-making based on empirical findings (Walton, Keegan, Martin, & Hallock, 2018). This experiential approach reinforces their understanding of how scientific methods are applied to investigate and answer research questions. TBPR also fosters critical thinking, a core dimension of scientific reasoning. Participation in research projects requires students to evaluate data rigorously, identify potential biases, and interpret results systematically. Ideally, TBPR encourages students to question, reflect, and discuss findings collaboratively, promoting higher-

order critical thinking skills (Zimmerman, 2007). In addition, such engagement nurtures creativity, as students are prompted to generate innovative solutions to problems identified during their research (Warli, Mawartiningsih, & Cintamulya, 2023). Through these processes, TBPR not only strengthens scientific thinking but also cultivates practical, analytical, and reflective skills essential for academic and professional success.

5.1. A Constructivist Perspective Related to the Implementation of TBPR

TBPR actively engages students in every stage of the research process, allowing them to gain hands-on experience in scientific thinking. By participating in authentic research tasks, students can bridge theoretical concepts learned in the classroom with practical applications, often achieving a deeper and more satisfying learning experience than through purely theoretical instruction (Azizah & Sulianto, 2018; Issa & Khataibeh, 2021). The implementation of TBPR in higher education is grounded in a constructivist learning perspective, which emphasizes active engagement and knowledge construction through social interaction. Constructivist theory posits that learners build understanding by participating in meaningful, collaborative tasks rather than passively receiving information. Within the TBPR model, students work together to investigate real-world problems, integrating prior knowledge with new experiences through discussion, reflection, and joint problem-solving. Studies show that TBPR promotes deeper learning by requiring students to negotiate ideas, challenge assumptions, and co-construct knowledge (Vespone, 2023). This approach aligns with Vygotsky's social constructivism, highlighting the role of social interaction and guided learning in cognitive development (Tohari & Rahman, 2024). Furthermore, empirical evidence demonstrates that TBPR enhances scientific thinking by engaging students in authentic inquiry processes that foster critical thinking and metacognition (Vuopala, Näykki, Isohätälä, & Järvelä, 2019).

The constructivist foundation of TBPR also cultivates student autonomy and self-efficacy. By engaging directly with authentic research tasks, students take ownership of their learning, make decisions, manage roles, and collaboratively solve problems, thereby increasing confidence and motivation (Calvo Martínez, Celini, Morales, Guaita Martínez, & Nuñez-Cacho, 2020; Jovanović, 2021). TBPR further supports the development of scientific communication skills, as students prepare research reports and present findings, learning to convey methods, results, and interpretations clearly and effectively (Hoffman et al., 2022; Yulian & Yuniarti, 2018; Yustina, Syafii, & Vebrianto, 2020). In addition, TBPR enhances objectivity in decision-making. Students make evidence-based decisions throughout the research process, from experimental design to data analysis, fostering logical and rational reasoning, a central component of scientific thinking (Drummond Otten & Fischhoff, 2023; Gasparatou, 2017; Murtonen & Salmento, 2019). Reflection and evaluation after completing projects encourage continuous learning and further development of scientific thinking skills. Moreover, the collaborative and active nature of TBPR provides a rewarding research experience that stimulates curiosity and encourages continued engagement with scientific inquiry (Carkinah, Felissa, & Rachman, 2024; Silvia, 2008). Ultimately, TBPR integrates multiple dimensions of scientific thinking within an authentic learning context, supporting the development of higher-order cognitive skills, teamwork, communication, and research competencies. The evidence from both previous studies and the present research indicates that TBPR has a positive and significant effect on students' scientific thinking, making it a highly relevant and effective pedagogical approach in higher education (Mikušková, 2023).

6. Conclusion

Based on the findings discussed in this study, it can be concluded that the implementation of TBPR effectively enhances students' scientific thinking skills in higher education. In addition to strengthening scientific reasoning, TBPR also improves students' abilities in communication, critical thinking, problem-solving, objective decision-making, collaboration, leadership, and adaptability. The

evidence demonstrates that TBPR is a robust pedagogical strategy, integrating collaborative learning with practical research experiences to provide a holistic framework for developing scientific competencies. Statistical analysis further confirms the positive and significant impact of TBPR on students' scientific thinking, underscoring its value for educators seeking to foster meaningful learning and prepare students for success in both academic and professional contexts.

However, several limitations of this study should be acknowledged. The research was conducted within a specific academic program and discipline, which may limit the generalizability of the findings to other fields or institutional settings. Additionally, the sample size and the duration of the intervention may not fully reflect the long-term effects of TBPR on students' scientific development. Individual differences, such as learning styles, prior knowledge, and instructor effectiveness, were not extensively examined and could influence outcomes. Future research should consider more diverse samples, longitudinal designs, and cross-disciplinary applications to validate and extend the conclusions drawn in this study.

7. Suggestion

Based on the findings and limitations of this study, it is recommended that higher education educators adopt the TBPR model as an innovative pedagogical approach to enhance students' scientific thinking and broader 21st-century competencies. Institutions should provide professional development and support systems to enable instructors to implement TBPR effectively, including training in collaborative learning design, project facilitation, and formative assessment practices. To strengthen future applications, researchers are encouraged to conduct longitudinal and cross-disciplinary studies involving larger and more diverse student populations. Furthermore, integrating digital tools and interdisciplinary themes into TBPR could enrich learning experiences and better equip students with the skills necessary for real-world problem-solving in both academic and professional contexts.

Declarations

Author Contributions. N.B.S was responsible for conceptualization, writing, and data collection. S.N.A contributed to writing and data collection. U.I was engaged in data analysis, writing, and language editing. W.S.U undertook data collection and data validation. A.D.B handled data processing, analysis, and correspondence. All authors reviewed the manuscript and approved the final version for publication.

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Ethical Approval. All research procedures involving human participants, including lecturers and undergraduate students, were carried out in accordance with institutional ethical standards. Informed consent was obtained from all participants prior to their involvement in the study.

Data Availability Statement. The primary data contained in this study can be obtained upon request to the corresponding author

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