BIO-INOVED
Jurnal Biologi-Inovasi Pendidikan
Volume 7, Issue 3, October 2025 page. 500-509

P-ISSN : 2684-9062 | E-ISSN : 2714-9803
https://ppjp.ulm.ac.id/journal/index.php/bino
DOI: 10.20527/bino.v7i3.22704

Students' collaboration skills and communication skills through research mini project learning

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Article Information

Keyword:
Research mini project learning; Collaboration skills; Communication skills

Kata Kunci:
Pembelajaran proyek mini riset; Keterampilan kolaboratif; Keterampilan komunikasi

History:
Received : 03/06/2025
Revised : 24/10/2025
Accepted : 28/10/2025
Published : 30/10/2025

Abstract

Twenty-first century skills require students not only to master theoretical knowledge but also to work effectively and communicate ideas clearly in various contexts. Based on this condition, two key competencies are needed to meet these demands: collaborative skills and communication skills. Collaboration is essential for enabling students to work in teams to solve complex problems, while effective communication supports students in expressing ideas, arguing logically, and building productive professional interactions. This study is important as it aims to examine the extent to which mini research project-based learning can develop students' collaborative and communication skills. The research employed a quantitative descriptive approach with a sample of 40 students. The study was conducted over three trials. Data on collaborative skills were collected using a questionnaire instrument as the primary data and observation sheets as supplementary data, while communication skills were measured using observation sheets. The results showed that students' collaborative skills improved from the first to the third trial, and similarly, their communication skills also increased across the three trials. The findings of this study are expected to contribute to the development of more contextual, collaborative, and communicative learning models and serve as a reference for improving the quality of learning processes in higher education.

Abstrak. *Keterampilan abad 21 menuntut mahasiswa tidak hanya menguasai pengetahuan secara teoritis, namun juga mampu bekerja secara efektif dan dapat menyampaikan ide secara jelas dalam berbagai konteks. Berdasarkan kondisi ini, diperlukan dua kompetensi untuk menjawab kebutuhan tersebut, yakni keterampilan kolaboratif dan keterampilan komunikasi. Kolaborasi diperlukan agar mahasiswa mampu bekerja dalam tim untuk memecahkan masalah yang kompleks, sedangkan komunikasi yang efektif mendukung mahasiswa dalam menyampaikan gagasan, berargumentasi secara logis, dan membangun interaksi profesional yang produktif. Penelitian ini penting dilakukan dengan tujuan untuk mengkaji sejauh mana pembelajaran berbasis proyek mini riset dapat mengembangkan keterampilan kolaborasi dan keterampilan komunikasi mahasiswa. Jenis penelitian yang digunakan adalah penelitian deskriptif kuantitatif. Jumlah sampel yang digunakan sebanyak 40 mahasiswa. Penelitian dilakukan sebanyak tiga kali ulangan. Pengambilan data keterampilan kolaboratif menggunakan instrumen angket sebagai data utama dan lembar observasi sebagai data tambahan. Sedangkan keterampilan komunikasi menggunakan lembar observasi. Hasil penelitian membuktikan bahwa keterampilan kolaboratif mahasiswa mengalami peningkatan dari ulangan ke satu hingga ulangan ke tiga begitu juga dengan keterampilan komunikasi mahasiswa, mengalami peningkatan dari ulangan ke satu hingga ulangan ke tiga. Hasil penelitian ini diharapkan dapat memberikan kontribusi bagi pengembangan model pembelajaran yang lebih kontekstual, kolaboratif, komunikatif, serta menjadi rujukan dalam peningkatan kualitas proses pembelajaran di perguruan tinggi.*

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A. Introduction

Learning in 21st century is characterized a significant shift from conventional to more modern, technology-mediated approaches (Julian, 2022). Traditionally, teaching and learning activities took place within the physical classroom, where students sat at their desk facing the board, listened to the teacher explanations and passively absorbed the material being delivered. However, in recent years, the learning process has increasingly transcended the boundaries of the classroom. Instruction can now be conducted through hybrid learning models, online discussion using Learning Management System (LMS, and various digital platforms such as WhatsApp, google classroom, and other form of e-learning (Güneş & Bozna, 2018). Consequently, 21st century learning characterized by flexibility and accessibility-allowing students to learn anytime and anywhere through digital media. This transformation is often referred to as *phenomenal disruption or futuristic learning* (Mampane, 2020). In this context, education in the twenty-first century not only demands that students possess strong cognitive abilities but also comprehensive set of skills essential for lifelong learning (Brar, 2017). According to Zubaidah (2018) explained that there are seven core competencies required of learners in this era, among which collaboration and communication skills are fundamental.

Communication skills are indispensable skills for effective interaction in various contexts (Septikasari & Frasandy, 2018). These abilities encompass not only the capacity to express ideas orally, but also to listen actively, pose relevant questions, respond constructively to others' opinions and convey information in systematic and logical manner (Patriot & Jannah, 2022). Proficient communication enables individuals to ensure that the intended message is clearly understood by others. In the educational context, communication skills constitute one of the essential competencies that teacher must (Brar, 2017). Effective communication support teachers in explaining learning materials clearly and efficiently, fostering classroom management, and ultimately enhancing the overall quality of the learning process (Masfufah et al., 2023). Therefore, cultivating good communication habits is crucial, and one effective way to develop these skills through active engagement in teaching and learning activities. Sumaiya et al. (2022) further emphasise that communication competence can be strengthened through consistent learning and deliberate practice.

Collaboration skills refer to the ability to work effectively with peers in order to achieve shared objectives (Zubaidah, 2018; Hidayati et al., 2021; Simanjuntak, 2019). These skills are essential to cultivate in students, as they help mitigate detrimental traits such as the *crab mentality* and selfishness, while simultaneously fostering empathy and respect for the perspectives and contributions of others (Mampane, 2020). Collaborative learning also enhances the effectiveness of the educational process by encouraging active engagement-both individually and in groups- and facilitating the exchange of ideas, knowledge, and information (Munfiatik, 2023). Furthermore, such learning environments contribute to more meaningful educational experiences, enabling students to retain acquired material over extended periods (Fitriasari et al., 2020).

Collaborative skills are among the essential competencies in higher education, supporting the development of graduate profiles that are communicative, adaptive, and capable of working effectively In teams (Pertiwi et al., 2023). In the context of higher education, collaboration is not limited to merely working within the same group (Afriadi et al., 2024); rather, it encompasses the ability to share roles and responsibilities, manage conflicts constructively, listen actively, respect differing opinions, and work collectively toward common goals. Reflection conducted by researcher with students at the end of the semester revealed that most students perceived group work as simply dividing task, with each member completing their portion independently, often without meaningful discussion or interaction. Furthermore, some group members remained passive, resulting in imbalanced contributions and unequal workloads. Such condition frequently led to tension and conflict among group members, ultimately hindering the learning process. Active students often felt overburdened due to the disproportionate workload, while less active students experienced a lack of confidence to fully engage. In addition to collaboration skills, students' communication skills during learning activities also presented difficulties-particularly in presentation and question and answer activities. Approximately 60% of students were unable to formulate arguments systematically, articulate ideas clearly, or present data accurately and objectively.in response to these issues, there is a need for learning strategies that foster both collaborative and communication skills in response to these issues, there is a need for learning strategies that foster both collaborative and communication skills. One such strategy is the implementation of mini research-based project learning. This approach involves students in a simplified research process, including research design, data collection, and reporting results through academic presentation (Heryana et al., 2023). One of the key advantages of this method is that it provides students with authentic experiences in teamwork and scientific communication.

Extensive research has been conducted on mini research project-based learning, including studies by Listiani & Dirgantoro (2023); Daulae et al. (2018); Budiono et al. (2024); Ekanara et al. (2021); and Padma & Sridhar (2015). However, there is a notable gap in the literature regarding the application of mini

research project-based learning specifically to assess collaboration and communication skills. This study, therefore, aims to examine the impact of mini research project-based learning on the collaborative and communication skills of Biology Education students, particularly those preparing to become future teachers.

B. Material and method

The present study employed a descriptive quantitative research design. Its primary objective was to describe students' collaboration and communication skills within the context of mini research-based project learning. Following the implementation of the treatment, systematic observations were conducted to examine students' collaborative abilities and scientific communication skills as demonstrated during learning activities. The population of this study comprised 80 sixth-semester Biology Education students, while the sample consisted of 40 students, selected through random sampling. The research was carried out within the Plant Ecology course. The research procedure was implemented in two stages, namely:

Preparation stage

The preparation stage involved several key activities: 1). A survey of potential research sites was conducted. Based on the survey result, three locations were selected: Lunto Rice Field Forest, South Mountain Forest, and mangrove forest. The selection of these sites was based on considerations such as forest area, safety level, and species diversity. 2). Guidelines for implementation the mini research -based learning project were developed to ensure uniformity and clarity in execution. 3). Research instruments were designed to assess students; collaborative and scientific communication skills. 4). A report template for documenting the mini research project activities was prepared. 5). Groups and observers were then assigned. Students were divided into eight groups, each consisting of five members.

Implementation stage

The implementation stage consisted of four main activities: 1). Conducting a survey of the research site. Students were invited to visit the designated research locations to identify potential research topics and formulate suitable research titles. The expected outcome of this activity was that students would be able to develop research titles based on their initial field exploration. 2). Design the project plan, gathering information, and determining appropriate methods. These activities were carried out collaboratively in groups within the classroom setting. Students discussed the research plans based on the predetermined titles and conducted literature reviews by consulting easily accessible national journals relevant to their research focus. 3). Collecting and analysing data. Data collection was conducted when students carried out their research in the designated forest area. Each group gathered data in accordance with the research instruments previously developed and subsequently performed data analysis based on their findings. 4). Communicating research result through presentation and discussion activities. At this stage, students presented their research finding and engaged in academic discussion to reflect on and validate their results.

At this stage of implementing the mini research project learning, three iterations were conducted. The first implementation (U1) took place in the Lunto Rice Field Forest. The second (U2) in the South Mountain Forest, and the third test (U3) in the Mangrove Forest.

Research Instrumentation

The dependent variables measured in this study were collaboration skills and communication skills. Both variables were assessed using observation sheet. The observation instruments for measuring collaboration skills was developed based on the collaboration skill indicator proposed by Farisi (2021). The indicators are presented in Table 1. Meanwhile, the assessment indicators for scientific communication skill were adapted from Afriani et al. (2019). The indicators used to evaluate students' scientific communication skills are presented in Table 2.

The implementation of mini-research project learning was conducted by referring to the stages of PJBL adapted from Saenab et al. (2019), while integrating mini-research elements as proposed by Islawati and Samsudin (2024). Data related to students' collaboration skills were collected from learning activities summarised in Table 3. The primary instrument used to gather data on collaboration skill was a questionnaire, supported by observation sheet (LO) as supplementary data sources. Observation Sheets (LO) were employed as supplementary data sources. The use of both questionnaire instruments and LO to assess collaboration skills was also implemented by Andriyatno et al. (2024). The questionnaire administrated was an attitude scale adapted from Shofiyah et al. (2022), comprising the following response options:

(0) : Never
(1) : Sometimes
(2) : Usually
(3) : Regularly
(4) : Always

Meanwhile, students' communication skills were measured using observation sheets. Data on communication skills were collected during the presentation sessions. With each student assessed individually.

Table 1 Collaboration skills indicators

Indicators	Sub indicators
Collaboration	- Engaging in effective collaboration within group
	- Demonstrating respectful collaboration within a diverse group
Responsibility	- Sharing-responsibility in collaborative task
	- Demonstrating initiative and the ability to self- manage
Compromise	- Engaging deliberation and consensus-based decision-making within the group.
Communication	- Conveying ideas clearly and effectively during group collaboration.
Flexibility	- Making constructive individual contributions to the group
	- Adapting to the working styles and needs of team members.

(Source: Farisi, 2021)

Table 2 Indicators of scientific communication skills

No	Dimension	Indicator
1	Problem identification	Stating the purpose of the problem clearly and accurately.
2	Problem solving process	Outlining systematic work steps and proposing appropriate problem-solving strategies.
3	Data presentation	Presenting relevant data in the form of tables, graphs, or diagrams to support findings.
4	Reasoning and argumentation	Providing logical reasoning to explain experimental result or phenomena
5	Conclusion drawing	Formulating conclusions that are consistent with the data and analysis.
6	Scientific presentation	Communicating experimental results effectively, both orally and in written form.

(Source: Afriani et al., 2019)

Table 3 The data collection and instruments based on student activities

Stage	Student activities	Data and instrument
Introduction	1. Forming a project working group. 2. Introducing project-based learning implementation plans. 3. Conducting a survey of the research location to determine the idea/title of the research.	Collaboration skills, with observation sheet (LO) instruments.
Essential Question	1. Discuss with the working group that leads students to find ideas/research titles to be carried out.	Collaboration skills, with observation sheet (LO) instruments.
Research and write	1. Review the literature to determine methods, research designs, prepare tools and materials to be used in research.	Collaboration skills, with observation sheet (LO) instruments.
Product Creation	1. Conduct field research in a predetermined location. 2. Record the data of research results according to the title/idea of the research.	Collaboration skills, with observation sheet (LO) instruments.
Presentation	1. Presenting research results data and Q&A.	Communication skills, with observation sheet (LO) instruments.
Evaluation and reflection	1. Filling out self-assessment.	Collaboration skills, with questionnaire instruments.

(Source: Saenab et al., 2019)

Data analysis techniques

The data analysis were analysed using descriptive statistical techniques aimed at students' collaboration and scientific communication skills throughout the learning process involving the implementation of mini-research-based project learning.

a) Collaborative skills data analysis techniques

The data analysis of students' collaborative skill was conducted through calculating students' responses, determining the percentage of students' responses using the Formula 1, and interpreting the questionnaire responses based on the established categorisation criteria, as presented in Table 4.

$$\% = \frac{\text{Numberof student answer}}{\text{Maximum Score}} \times 100\ \%\text{.....Formula 1}$$

Table 4 Categorization of collaborative skills

Percentage (%)	Category
0-20	Very weak
21- 40	Weak
41 – 60	Enough
61 – 80	Strong
81 - 100	Very powerful

(Source: Hairida et al., 2021)

b) Communication ability data analysis techniques
The analysis of students' communication skills was conducted using the Formula 2. The categorisation of students' communication skills is presented in Table 5.

$$\text{Score} = \frac{\text{Score Obtained}}{\text{Maximum Score}} \times 100\ \%\text{.....Formula 2}$$

Table 5 Categorization of skill communication

Score	Category
100-81	Highly skilled
80-61	Skilled
60-41	Quite skilled
40 - 0	Less skilled

(Source: Patriot & Jannah, 2022)

C. Results and discussion

Based on the results of the research that has been conducted, data related to collaboration skills and communication skills are obtained as follows.

Collaborative skills
The assessment of collaborative skills was undertaken during student's learning activities in a mini research project. In this project, students worked collaboratively in groups to design a research study based on their initial field observations. These preliminary observations were conducted in the research forest situated around the UBT campus area to generate potential research ideas (see Figure 1).

This research was conducted in three phases. The first test (U1) took place in the Lunto Rice Field. The second test (U2) in the South Mountain Forest and the third test (U3) in the Mangrove Forest. During these activities, students were actively involved in determining research titles, formulating problems, designing experiments and instrument, collecting research data, and communicating their findings. Data were collected through direct observation and questionnaire assessments. The questionnaire assessment was administered after the completion of the learning process in each phase. Through the learning process, the researcher observed and evaluated students' collaborative skills based on five main indicators: collaboration, responsibility, compromise, communication, and flexibility. The data on students' collaborative skills are presented in Table 6.

Figure 1 The students are collaboratively engaged in formulating their research ideas and outlining the procedural steps

Table 6 Assessment of collaboration skills with questionnaires

Indicator	U1 (%)	U2 (%)	U3 (%)	Average (%)	Category
Collaboration	56,6	77,9	82,1	72.2	Strong
Responsibility	66,3	74,8	79,5	73.53	Strong
Compromise	68	74	81,4	74.47	Strong
Communication	61	76	79,3	72.10	Strong
Flexibility	69	75,2	84,5	76.23	Strong
Average	**64.18**	**75.58**	**81.36**		
Category	**Strong**	**Strong**	**Strong**		

Description: U = repetition

Based on Table 6, the average level of student's collaborative skills across U1 to U3 is categorized as strong. Each indicator within U1-U3 also falls within the strong category. Moreover, a progressive increase in the average level of students' collaborative ability was observed from U1 to U3. Although the overall performance is classified as strong, the score distribution primarily falls within the range of 61-70 and 71-80, as presented in Table 7.

At U1, students demonstrated the lowest average level of collaborative skills compared to U2 and U3. Observation revealed that several groups at U1 experienced difficulties in task distribution and managing group dynamics. Some members tended to be passive, locked confidence in expressing their opinions, while others dominated discussion and often monopolized decision-making processes. Consequently, lecturers are required to take an active role in facilitating group dynamics through periodic reflection, providing constructive feedback, and fostering cooperative attitudes. Such facilitation enables students to better recognize each member's role and enhance their sense of responsibility towards the group. This approach resulted in an observable improvement in students' collaborative skills in U2 and U3. Overall, the progressive increase from U1 to U3

indicates that the implementation of mini research-based learning contributes significantly to enhancing student collaboration. Through mini research project, students not only engage directly in the research process but also develop essential teamwork skills by collaboratively formulating research questions, collecting and analysing data, and preparing research reports. These learning dynamics promote intensive interaction among group members, which serves as key factor in the development and reinforcement of collaborative skills. This finding is consistent with the study conducted by Murniati et al. (2025).

Table 7 Score earning range per individual

Indicator	Repetition	Score range					
		40-50	51-60	61-70	71-80	81-90	91-100
Collaboration	U1	12	18	10			
	U2			1	24	4	1
	U3				12	17	1
Responsibility	U1		1	22	7		
	U2			4	22	4	
	U3			7	21	1	1
Compromise	U1		2	15	13		
	U2			6	20	4	
	U3				26	4	
Communication	U1		14	16			
	U2			1	23	6	
	U3			12	16	2	
Flexibility	U1		2	14	14		
	U2			5	21	2	
	U3			4	17	8	1
Total		**12**	**37**	**117**	**236**	**52**	

Collaborative skills in mini-research projects learning are primarily facilitated during the stages of "*Essential Question, Research and writing, and Product Creation"*. At these stages, students are observed to work collaboratively, share tasks, express opinions, provide and receive feedback, and solve problem as a team. Naturally, the mini-research projects model fosters a learning environment that encourages active student engagement in teamwork, group discussions, and collective decision-making (Lestari & Rachmawati, 2024). In this context Students do not merely act as recipients information but also seekers and processors of knowledge who must collaborate in designing, implementing, and analysing data from their research activities. Consequently, collaborative skills develop as a result of authentic interactions, shared responsibilities, and the pursuit of common goals within the team. Mini research project based learning requires a clear division of task among group members (Widiantie et al., 2021). This division encourage students to engage in meaningful collaboration and discussion with their peers for instance, in determining who searches for literature, processes data, or communicates research finding during presentations., processes data, communicates research results data during presentations. Such task sharing processes help students learn to negotiate, appreciate each member's contribution, and foster a sense of responsibility for their respective roles. Through these continuous and reciprocal interactions, collaborative skills are developed organically (Gannar & Kilani, 2025).

In addition, mini-research project learning activities are conducted in groups, enabling students to share a common goal and to recognize the significance of individual contributions in achieving collective outcomes (Zhang, 2023; Hemi et al., 2024). Emotional and intellectual engagement in completing research tasks makes the learning process more meaningful and fosters collective awareness (Saunders & Robins, 1989). The mini-research projects learning process requires students to think critically, articulate ideas, and evaluate one other's perspectives (Leksono et al., 2020). This activity encourages students to practice active listening, provide constructive feedback, and reach consensus in solving problems. These findings demonstrate that mini research projects-based learning promote not only cognitive development but also the affective and social dimensions of learning, particularly empathy, openness, and effective teamwork. This is consistent with Vigotsky's constructivist theory, which underscore the importance of social interaction in learning and posits that the learning occurs most effectively within a social context (Tohari & Rahman, 2024). As a form of project-based learning, the mini-research approach creates a collaborative environment that enables students to co-construct knowledge, resolve conflicts constructively, and provide mutual support throughout the learning process.

Communication skills

Data on students' communication skills were collected during their presentations. The data collection process employed an observation sheet (LO)as the main instrument. The results, presented in Table 8, indicate

a progressive improvement in students' communication skills from U1 to U3, shifting from the skilled to the highly skilled category. The enhancement of students' communication skills in mini research project learning is primarily facilitated during the *research and writing, and presentation* stages.

Table 8 Student communication skills

Indicator	U1	U2	U3	Averages	Category
A	80	85	88	84.3	Highly skilled
B	75	78	82	78.3	Skilled
C	78	82	85	81.6	Highly skilled
D	76	80	83	79.6	Skilled
E	74	77	81	77.3	Highly skilled
F	72	75	79	75.3	Skilled
Average	**75.8**	**79.5**	**83**		
Category	**T**	**T**	**ST**		

Description: A = State the purpose of the problem; B = Write down work steps and problem-solving solution; C = Stating the data in tables/graphs; D = Express conclusions about the problem; E = Present the results of the experiment; F = State reason logically; T = Skilled; and ST = Highly skilled

At the "*research and write"* stage, students engage in intensive discussions to determine research methods, design experimental procedures, and prepare the tools and materials required. These discussions encourage students to articulate ideas that support the implementation of their research. Similarly, the *presentation s*tage requires students to orally communicate their research finding to others. During this stage, they are expected not only to present their work verbally but also to defend their ideas and respond to questions related to their findings. This process trains students to express opinions and analyses both orally in writing, whether to group members or lecturers. Through this experience, students develop their argumentative competence, practice critical yet constructive response, and cultivate clear, structured, and evidence-based communication patterns grounded in their research outcomes.

Mini-research project learning requires students to work collaboratively in groups to formulate research question, collect and analyze data, and communicate research outcomes through both oral presentations and written reports. This process inherently promotes active communication among team members, taking the form of discussions, negotiations, and joint decision making. As highlighted by Li (2024), strong communication skills facilitate effective teamwork in completing academic tasks. Accordingly, communication competence becomes a crucial attribute for students to master, particularly in articulating ideas in a logical, systematic, and evidence-based manner.

Mini-research learning positions students as active agents in the process of constructing and presenting knowledge through small-scale, group based research activities (Wahono et al., 2025). With In this process, communication becomes a crucial and inseparable component both in interactions among group members and in exchanges with others. Furthermore, interpersonal communication within groups also develops, as evidenced when students provide constructive feedback, express disagreement politely, and engage in ethical dialogue during discussion or presentation of the research findings. This aligns with Vigotsky's theory of social constructivism, as cited in Tohari and Rahman (2024), which posits that learning occurs most effectively through social interaction. Consistently Dewi et al. (2024) found that in the context of mini research projects learning, students collaboratively construct knowledge through shared discussion and exploration. Such interactions serve as a vital space for developing students' communication competencies (Saenab & Virninda, 2017).

In general, numerous studies on *Project Based Learning* (PjBL) have been conducted, particularly highlighting its contributions to enhancing critical thinking, creativity, and learner autonomy. However, this study offers a novel perspective by integrating a mini-research approach- a form of Project-based learning that involves conducting small-scale research collaboratively and reflectively. Learning Project-based on the mini-research model represent an innovative development of traditional PjBL. This study combines two core pedagogical-approaches; project-based activities and scientific methods. Through this integration, students are not only expected to complete the project tasks but also guided to follow the systematic stages of the scientific method, including problem formulating, data collecting, field investigation, data analysis, and presentation of research report. This synergy between project-based learning and the scientific method aims to foster a meaningful, contextual, and application-oriented learning experience while simultaneously developing students' collaborative and communicative competencies throughout the learning process.

The integration of Mini-research within project learning-provide a strategic pathway for cultivating essential 21st-century competencies, particularly collaboration, communication, critical thinking, and creativity. These competencies are not developed through theoretical instruction alone but through

authentic learning experiences that demand active engagement, reflection, and problem solving within real-world contexts. Mini-research learning situates students in authentic investigative scenarios that mirror the process of scientific inquiry, thereby enabling them to connect theoretical knowledge with empirical practice. Through the collaborative design and execution of research project, students learn to negotiate ideas, articulate arguments, evaluate evidence, and construct knowledge. This aligns with global educational paradigms that emphasise learner agency, interdisciplinary integration, and the development of higher-order thinking skills necessary for navigating complex professional and societal challenges in the 21st century. Consequently, the mini-research approach not only strengthens students' scientific literacy but also enhances their readiness to function as adaptive, reflective, and collaborative problem-solvers in diverse academic and professional settings.

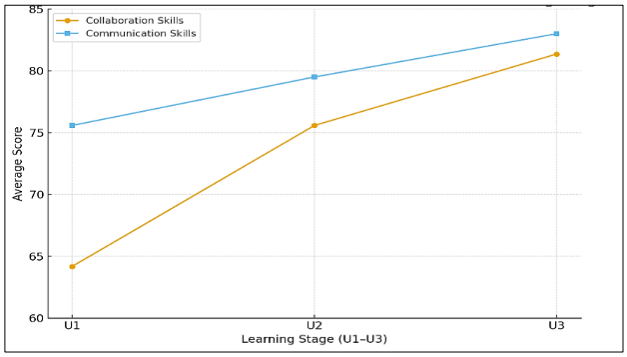

Figure 2
Trends in students' collaboration skills across learning cycles (U1-U3)

As shown in Figure 2, both collaboration and communication skills demonstrated a consistent upward trend from U1-U3. The most substantial improvement occurred in collaboration skills, which increased from 64.18 (U1) to 81.36 (U3). This suggest that repeated engagement in mini-research cycles strengthened students' ability to coordinate task, share responsibilities, and make joint decisions effectively. Communication skills also showed a steady rise from 75.58 to 83, indicating that continuous involvement in data presentation, discussion, and findings imply that the integration of mini-research within project-based learning effectively promotes both interpersonal collaboration and scientific communication competence, aligning with the principles of social constructivism and experiential learning theory.

In summary, this study highlights the novelty of integrating mini-research into project-based learning as an innovative pedagogical approach that bridges theoretical understanding with practical inquiry. The findings demonstrate that the combination of project-oriented learning and the scientific method not only enhances students' collaborative and communicative competencies but also fosters a deeper engagement in critical and reflective thinking. This integration provides a more authentic, meaningful, and contextually grounded learning experience, allowing students to internalize the processes of inquiry and team work that are essential in contemporary scientific and educational practice. The implications of this research suggest that educators should consider incorporating mini research projects as a core component of learning design to strengthen students' 21st-century competencies and scientific literacy. Furthermore, future studies may extend this research by exploring the long-term effects of mini-research project implementation across different disciplines, educational levels, and learning modalities, as well as by examining its potential to support metacognitive development and lifelong learning dispositions.

D. Conclusion

This study demonstrates that the implementation of mini-research-based project learning effectively enhances students' collaboration and communication skills. The consistent increase in the two competencies across learning cycles (U1-U3) demonstrates that structured research-based project activities can create an active, reflective, and cooperative learning environment. The integration of project-based learning with the scientific method encourages students not only to develop critical and analytical thinking but also to build empathy, openness, and mutual respect in teamwork. Theoretically, this research contributes to the enrichment of project-based learning models by integrating a mini research approach that combines scientific inquiry and collaborative practice. Practically, the findings offer a pedagogical strategy for lecturers in higher education especially in teacher education programs to cultivate 21st century skills through authentic, research-oriented learning experiences. Future research is recommended to explore the long-term impact of mini-research project learning on students' scientific literacy and problem-solving abilities, as well as its implementation across different disciplines and learning contexts.

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