RADIAN Journal: Research and Review in Mathematics Education
https://journal-fkip.unsika.ac.id/index.php/radian/
e-ISSN: 2961-7049
Volume 4 Number 4
December 2025

Improving Students' Collaboration and Communication Skills through Project-Based Learning Model and a Deep Learning Approach in Phase F Statistics Material

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Disubmit: 03 December 2025; Direvisi: 18 December 2025; Diterbitkan: 30 December 2025
DOI: 10.35706/radian.v4i4.13265

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ABSTRACT
Collaboration and communication skills are part of the eight dimensions outlined in the graduate profile of the Merdeka Curriculum. The deep learning approach emphasizes three core principles: mindful, meaningful, and joyful learning. When integrated into project-based learning, this approach is expected to enhance students' collaboration and communication abilities. This study aims to descriptively analyze the impact of implementing project-based learning with a deep learning approach in Phase F statistics material on students' collaboration and communication skills. The statistical topics covered in this study include scatter plots, linear regression equations, and correlation analysis, with the aid of Microsoft Excel. This research uses a qualitative descriptive method. The instruments used consisted of observation sheets to assess collaboration and communication skills, as well as student response questionnaires. The findings indicate that after the implementation of project-based learning with a deep learning approach, students' collaboration skills reached 77.25%, categorized as good, while communication skills reached 65.75%, categorized as enough. Meanwhile, student responses to the implementation of this approach in Phase F statistics material were very good. Based on the findings, it can be concluded that the implementation of project-based learning with a deep learning approach in statistics material at Phase F has a positive impact on collaboration and communication skills. This study provides implications regarding the description of the results of implementing the project-based learning with a deep learning approach on collaboration and communication skills, as well as the challenges encountered during the implementation of the project-based learning with a deep learning approach.

Keywords: Project Based Learning; Deep Learning; Collaboration Skills; Communication Skills; Statistic

ABSTRAK
Kemampuan kolaborasi dan komunikasi adalah bagian dari 8 dimensi pada profil lulusan pada kurikulum merdeka. Pendekatan deep learning atau pembelajaran mendalam menekankan tiga prinsip utama yaitu pembelajaran mindfull, meaningfull, dan joyfull dengan diintegrasikan dalam project-based learning diharapkan dapat mengasah kemampuan kolaborasi dan komunikasi peserta didik. Tujuan dalam penelitian ini adalah untuk menganalisis dampak terhadap hasil penerapan project-based learning dengan pendekatan deep learning pada materi statistika fase F terhadap kemampuan kolaborasi dan komunikasi peserta didik. Materi statistika yang digunakan mencakup diagram pencar, persamaan garis regresi linear, dan analisis korelasi dengan memanfaatkan aplikasi Microsoft Excel. Metode dalam penelitian ini adalah metode deskriptif kualitatif. Instrumen yang digunakan berupa lembar observasi kemampuan kolaborasi dan komunikasi, serta angket respon peserta didik. Hasil temuan menunjukkan bahwa setelah penerapan penerapan project-based learning dengan pendekatan deep learning keterampilan kolaborasi peserta didik mendapat hasil sebesar 77,25% dengan kategori baik dan keterampilan komunikasi mendapatkan hasil 65,75% dengan kategori cukup. Sementara, respon siswa terhadap penerapan project-based learning dengan pendekatan deep learning pada materi statistika fase F menunjukkan sangat baik. Berdasarkan hasil temuan dapat disimpulkan bahwa penerapan project-based learning dengan pendekatan deep learning pada materi statistika fase F memberikan dampak positif terhadap keterampilan kolaborasi dan komunikasi. Penelitian ini memberikan implikasi tentang deskripsi hasil implementasi model PjBL dengan pendekatan deep learning terhadap kemampuan kolaborasi dan komunikasi serta tantangan yang dihadapi selama implementasi model PjBL dengan pendekatan deep learning.

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Kata Kunci: *Project Based Learning; Pembelajaran Mendalam; Kemampuan Kolaborasi; Kemampuan Komunikasi; Statistika*

INTRODUCTION

In 2020, Indonesia introduced the *Merdeka Curriculum* on a trial basis and gradually implemented it nationwide in 2022 (Hamdi et. al., 2022). This curriculum emphasizes eight graduate profile dimensions: faith and devotion to God Almighty, citizenship, critical reasoning, creativity, collaboration, independence, health, and communication. To achieve these competencies, appropriate learning approaches are required. One proposed approach is *deep learning* (Sari & Arta, 2025).

Deep learning emphasizes three key principles: mindful learning, meaningful learning, and joyful learning (Nabila et. al., 2025). Mindful learning builds awareness of the importance of studying and understanding the material (Rosiyati et. al., 2025). Meaningful learning ensures that knowledge is applicable in real life contexts (W. Fatihah & Wiji, 2025). Joyful learning creates a supportive and enjoyable learning environment (Feriyanto & Anjariyah, 2024). In addition, *deep learning* promotes three learning experiences: understanding, applying, and reflecting (Purwoko, 2025).

To support classroom implementation of *deep learning*, an appropriate instructional model is needed. *Project-based learning (PjBL)* is one such model, characterized by four features: starting with a driving question, developing projects as solutions, fostering collaboration, and strengthening communication (Miller et. al., 2021). PjBL emphasizes not only the final outcome of a project but also the process involved in developing it (Zhang & Ma, 2023). Its core steps include formulating essential questions, designing project plans, scheduling, monitoring implementation, testing results, and reflecting (Novianto et. al., 2018). PjBL can be integrated with deep learning because project development requires mindfull, meaningfull, and a joyfull atmosphere so that the resulting projects can have greater benefits and impact.

Collaborative and communication skills are often not considered as outcomes of the learning process, particularly in mathematics and science learning (Malik & Ubaidillah, 2021; Linda & Afriansyah, 2022; Sulastri, 2023). This is reflected in research findings that more frequently emphasize other abilities and skills. Collaboration skills refer to skills related to a person's interaction with others to achieve certain goals together (Talib et al., 2021). Indicators of collaboration skills include actively contributing within the group, being responsible for assigned tasks, being able to adapt within the group, and being able to accept differences of opinion within the group (Putri et al., 2025). Communication skills are the abilities to express ideas or opinions, either orally or in written form (Iksan et al., 2012; Ikhsan & Afriansyah, 2023). In this study, the communication skill measured is written communication in the form of a project presented as an infographic. Indicators of written communication skills include transforming the form of data presentation, using appropriate notations or symbols, graphs, sketches, or images, maintaining coherence in presenting results, and accurately drawing conclusions (Fatihah et. al., 2022). Collaborative and communication skills must continue to receive attention because they cannot be separated from the learning process as part of 21st-century skills. Collaboration skills are necessary to ensure that projects can be completed on time (Aziz & Nurachadijat, 2023). Meanwhile, communication skills are required so that the resulting projects can be disseminated to others through both oral and written communication (Novitasary, 2022).

Statistics is a core topic in the high school mathematics curriculum. In Phase F *Merdeka Curriculum*, students are expected to master scatter plots, linear regression, and regression equations to solve contextual problems. However, statistics is often perceived as difficult, as it is typically taught theoretically without contextual applications (Gumilar & Effendi, 2022). In fact, this material can be optimized if integrated with technology such as Microsoft Excel, so that

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learning becomes more meaningful and enjoyable, as well as relevant to solving real-life contextual problems.

Previous studies indicate the effectiveness of PjBL in mathematics. For example, (Lazić et. al., 2021) reported improved achievement in elementary mathematics; (Fisher et. al., 2021) (Karan & Brown, 2022) found enhanced problem-solving ability; (Rehman et. al., 2023) highlighted improvements in collaboration, critical thinking, and problem-solving; and (Anisa et. al.., 2023) noted gains in creative thinking. Furthermore, (Made et. al., 2024) demonstrated that STEM-based PjBL increases student engagement, collaboration, and communication. Studies on *deep learning* also show positive outcomes. Research on the implementation of *deep learning* in mathematics learning has also been conducted by (Mutmainnah et. al., 2025) whose findings revealed that applying *deep learning* in elementary school mathematics makes learning more active, meaningful, and enjoyable. Another study (Wijaya et. al., 2025) found that *deep learning* in elementary schools can enhance critical thinking skills, strengthen character, and increase learning motivation.

Based on previous research, no studies have been found that explicitly examine the implementation of PjBL with a deep learning approach in Phase F statistics material to develop students' collaboration and communication skills. Therefore, this study aims to descriptively analyze the impact of implementing PjBL with a deep learning approach in teaching statistics (Phase F).

METHOD

This study aims to descriptively analyze the impact of implementing PjBL with a deep learning approach in teaching statistics (Phase F). Therefore, a qualitative descriptive research method was employed. The study was conducted at a public senior high school in Lebak Regency, Banten Province, during January–February 2025. The sample in the study was class XII-4 consisting 38 students using selected simple random sampling. The research instruments included observation sheets to assess collaboration and communication skills, as well as a questionnaire to capture students' responses toward the implementation of PjBL with a deep learning approach in statistics (Phase F). The instruments used have been validated by expert judgement. The research procedure in this study consists of formulating and determining the research problems and objectives, developing research instruments, conducting the research, analyzing the data, and drawing conclusions. Data obtained from observations of collaboration and communication skills, along with student responses, were analyzed by calculating percentages and then describing the results. The percentage categories referred to (Putra et. al., 2023) in Table 1 are as follows:

Table 1. Category of Percentage

Percentage	Category
0 – 39	Very poor
40-54	Poor
55-69	Fair
70-84	Good
85-100	Very good

RESULTS AND DISCUSSION

PjBL with a deep learning approach in Statistics Phase F was carried out over 10 sessions using the six syntaxes of the PjBL model, namely: fundamental questions, designing project planning, creating a project schedule, monitoring project implementation, testing the results, and

reflecting on experiences. The PjBL with a deep learning approach in Statistics Phase F ran smoothly. The integration of the deep learning approach (mindful, meaningful, and joyful) aligned very well with the project-based learning model.

Some challenges encountered were that students were not yet familiar with the activities and stages of conducting research, and many students did not yet understand how to use Microsoft Excel. Mastery of technology in the 21st century is very important in the learning process because technology can facilitate learning (Maylitha et. al., 2022). To overcome this, the role of the teacher is crucial to ensure the learning process can be carried out effectively. The teacher's role is not only to teach but also to guide students so that their skills can be trained (Nurzannah, 2022).

The results of collaboration skills through PjBL with a deep learning approach in Statistics Phase F are presented in the Figure 1 as follow.

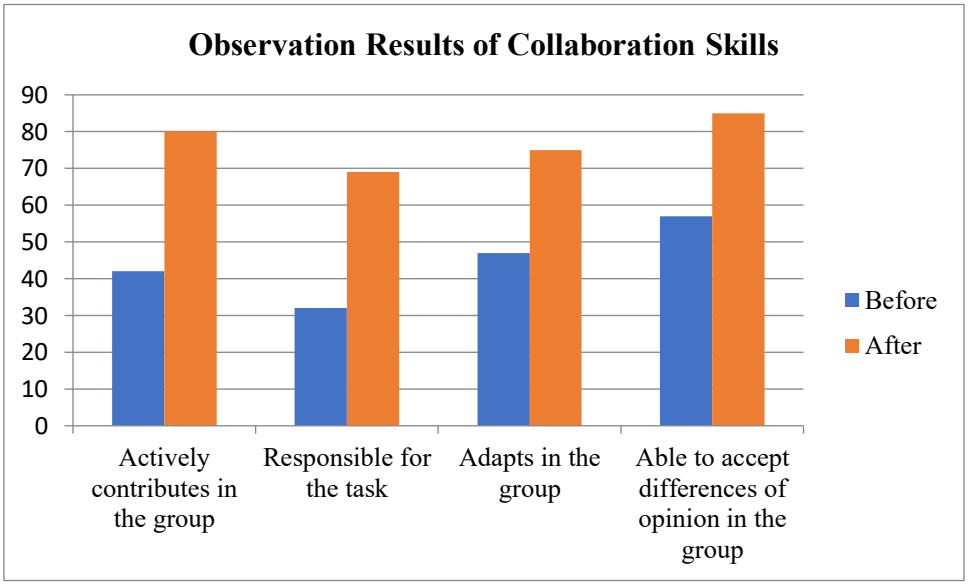

Figure 1. Observation Results of Collaboration Skills

The indicator of actively contributing in the group increased from 42% to 80%. The indicator of being responsible for tasks increased from 32% to 69%. The indicator of adapting within the group increased from 47% to 75%. The indicator of being able to accept differences of opinion within the group increased from 57% to 85%. The research results show that overall students' collaboration skills improved from 44.5% (low) to 77.25% (good). Based on these results, it can be seen that the indicator with the highest increase was the ability to accept differences of opinion within the group, while the lowest increase was in the indicator of being responsible for tasks. The low responsibility of students toward tasks needs to be trained because it is part of the character students must possess. According to (Silvi et. al., 2023) , students' responsibility can be trained through group counseling. Therefore, collaboration between subject teachers and guidance counseling teachers in schools is necessary.

Based on the research results, the implementation of the PjBL model can improve students' collaboration skills. This is in line with the opinions of (Rehman et. al., 2023) (Made et. al., 2024) who stated that the implementation of the PjBL model can enhance students' collaboration skills. This is also because PjBL is a complex form of learning that requires collaboration among students so that the project can be completed properly and on time, thereby fostering good collaboration between students (Aziz & Nurachadijat, 2023).

e-ISSN: 2961-7049
Volume 4 Number 4
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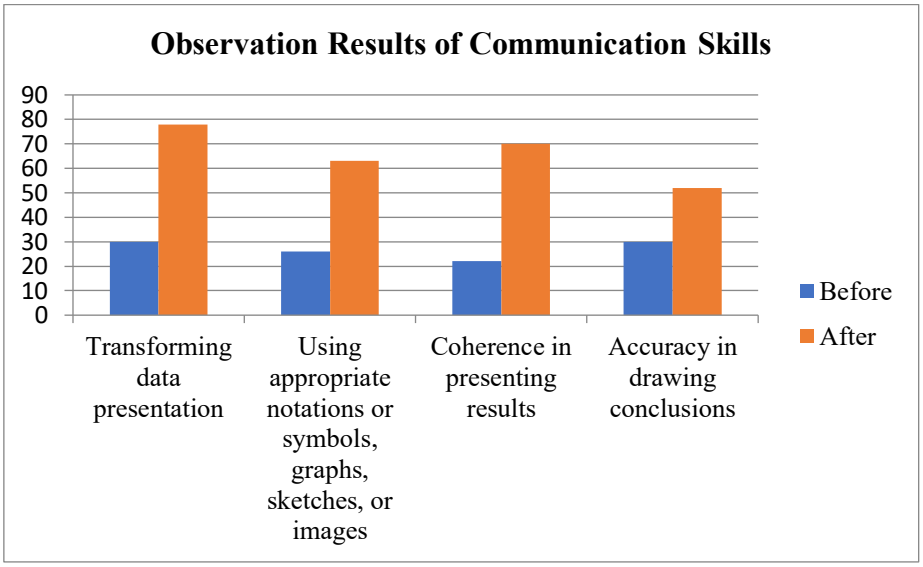

Figure 2. Observation Results of Communication Skills

The Figure 2 shows that the indicator of transforming data presentation increased from 30% to 78%. The indicator of using appropriate notations or symbols, graphs, sketches, or images increased from 26% to 63%. The indicator of the coherence of presenting results increased from 22% to 70%. The indicator of accuracy in drawing conclusions increased from 30% to 52%. Overall, the results indicate that students' communication skills improved from 27% (very poor) to 65.75% (fair). Based on these results, it can be seen that the indicator with the highest increase was transforming data presentation, while the lowest increase was in the indicator of accuracy in drawing conclusions. The low ability of students in drawing conclusions is due to their low literacy skills. Therefore, it is necessary to improve students' literacy through the application of appropriate learning models, learning approaches, or learning methods. According to (Suharyani et. al., 2023) literacy can be improved through the Teaching at the Right Level (TaRL) approach.

Based on the research findings, the implementation of the PjBL model can improve students' communication skills. This is consistent with the opinion of Taryono et al. (2019), who state that the application of a PjBL model can enhance students' communication skills. This is also because PjBL involves collaboration, making communication skills essential for collaboration to function effectively (Jannah et al., 2023). In addition, PjBL includes activities that require students to communicate project outcomes, both orally and in written form (Novitasary, 2022).

An example of students' communication skills in the form of written communication through creating an infographic of the results of a simple research project is as follows in Figure 3.

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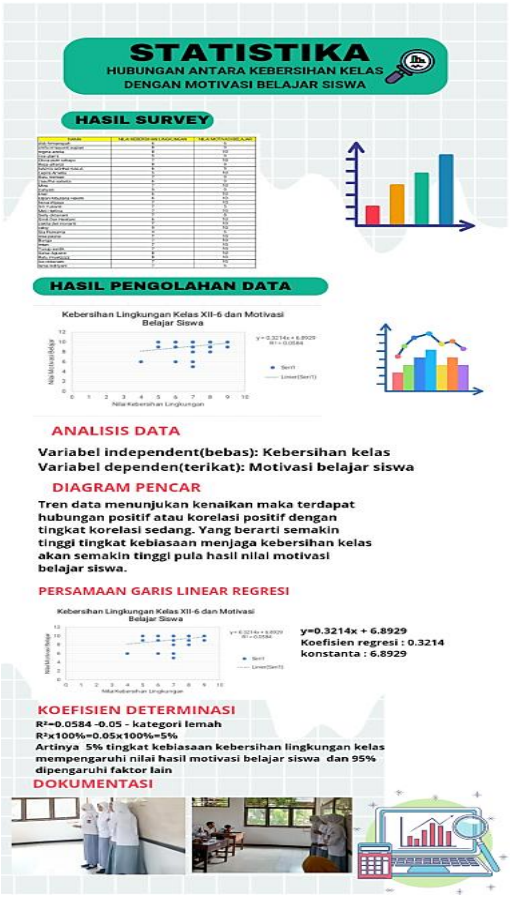

Figure 3. The Example Results of a Simple Research Project

The students' responses to the implementation of PjBL with a deep learning approach in phase F statistics material are presented in the following Figure 4.

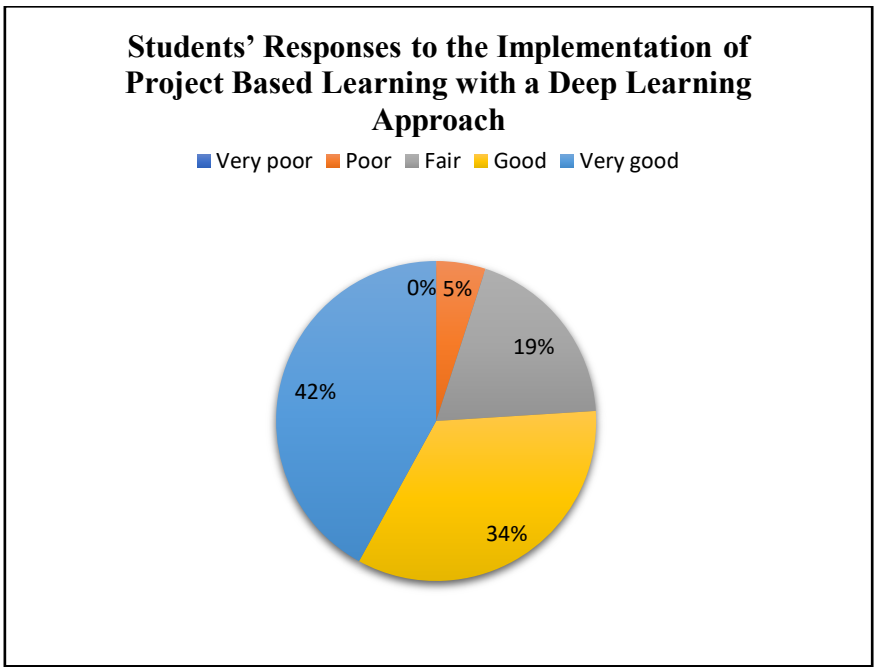

Figure 4. Students' Responses to the Implementation of Project Based Learning with a Deep Learning Approach

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Several factors that made students perceive the implementation of PjBL with a deep learning approach in phase F statistics material as very effective are that the learning process became more meaningful and enjoyable because it was directly applied to real-life examples rather than merely theoretical. This is in line with the opinion of (Damayanti & Afriansyah, 2018; Muslihah & Suryaningrat, 2021; Septiani & Asih, 2024; Suhermi et. al., 2025), who stated that contextual learning makes the learning process more meaningful. Furthermore, the use of technology, such as Microsoft Excel, also helped students better understand the material. This is supported by who argued that the use of technology not only facilitates students' learning but also increases their interest in learning. In addition, the implementation of PjBL with a deep learning approach in phase F statistics material also helped train students' collaboration and communication skills. This is consistent with the views of (Rehman et. al., 2023) and (Made et. al., 2024), who stated that PjBL can develop students' collaboration and communication skills.

CONCLUSIONS

The research results to the implementation of PjBL with a deep learning approach in Statistics Phase F show that students' collaboration skills improved from 44.5% (low) to 77.25% (good). Based on these results, it can be seen that the indicator with the highest increase was the ability to accept differences of opinion within the group, while the lowest increase was in the indicator of being responsible for tasks. The results indicate that students' communication skills improved from 27% (very poor) to 65.75% (fair). Based on these results, it can be seen that the indicator with the highest increase was transforming data presentation, while the lowest increase was in the indicator of accuracy in drawing conclusions. The low ability of students in drawing conclusions is due to their low literacy skills. Furthermore, students' responses to the implementation of PjBL with a deep learning approach in Statistics Phase F were categorized as *very good*. Based on the findings, it can be concluded that the implementation of project-based learning with a deep learning approach in statistics material at Phase F has a positive impact on collaboration and communication skills.

This study provides implications regarding the description of the results of implementing the project-based learning with a deep learning approach on collaboration and communication skills, as well as the challenges encountered during the implementation of the project-based learning with a deep learning approach. This study, however, has several limitations. The research design was restricted to qualitative descriptive methods, the scope was limited to statistics material in Phase F, and the skills measured were confined to collaboration and communication. Therefore, future research is recommended to employ experimental methods in order to generalize the findings, apply the approach to different subject matter, and investigate additional skills beyond collaboration and communication.

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