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# Analysis of Students' Collaboration Skills MAN Pinrang in Physics Learning Through the STEM Approach


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**ABSTRACT:** This study is an ex post facto study that is descriptive qualitative. The purpose of this study is to determine the collaboration skills of MAN Pinrang students in learning physics through the STEM approach. This research was conducted at MAN Pinrang in the odd semester of the 2023/2024 academic year, which was around September-October 2023. The population in this study were all MAN Pinrang class students with a total of approximately 1,050 students. While the sample was 32 students who were taken randomly using Simple Random Sampling. The instrument used was a questionnaire. The results of the questionnaire analysis showed that each average percentage of each indicator ranged from 75% - 83% or was in the high or even very high category. Thus, it can be concluded that students at MAN Pinrang have good collaboration skills in learning physics with the STEM approach.



**KEYWORDS:** Skills, Collaboration, STEM, Physics Learning, 21st Century Skills


## I. INTRODUCTION

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In response to the challenges of the Fourth Industrial Revolution, Indonesia's education system is directed toward equipping students with 21st-century competencies—namely critical thinking, creativity, communication, and collaboration (4C). Among these, collaboration is increasingly relevant in a globalized context, as it enables individuals to work effectively in heterogeneous and dynamic teams (Paramita et al., 2020). Collaboration is not only a workplace demand but also an effective learning method to cultivate inclusive, tolerant, and solution-oriented learners (Rahmawati et al., 2019; Shofiyah et al., 2022). In physics education, this skill is particularly crucial, as learning physics involves not only abstract conceptual understanding and mathematical formulation but also scientific inquiry, discussion, and contextual problem-solving.

STEM (Science, Technology, Engineering, and Mathematics) has emerged as a dynamic and integrative pedagogical approach that actively engages students in exploring and solving real-world problems by connecting interdisciplinary knowledge. The STEM framework supports collaborative learning by encouraging students to work together on authentic, challenge-based projects (Sumaya et al., 2021; Megawati et al., 2023). The STEM learning process involves key stages such as problem identification, model development and application, investigation, data analysis, and communication of findings (Wibowo, 2018). These stages require equitable group participation and foster collaboration through distributed responsibilities and shared roles.

Research on collaborative STEM learning highlights the importance of structured teamwork environments that integrate real-life context, role distribution, and shared responsibility. Ahmed et al. (2024), using the Theory of Planned Behavior (TPB), implemented interventions that included project contextualization, accountability frameworks, and group management guidelines. Their results showed significant improvements in group cohesion, participation, and goal clarity. Similarly, Kilty and Burrows (2022) demonstrated that integrated STEM projects in informal educational settings could foster meaningful interdisciplinary partnerships, increase team autonomy, and yield high-quality learning products.

Nikiforos and Kolyvas (2020) also found that collaborative STEM environments, particularly those involving educational robotics, promote student engagement and community building. Through cross-disciplinary collaboration, students developed not only technical competencies but also motivation and responsibility for learning. Ramachandran (2025) emphasized the role of collaborative techniques such as peer instruction and group discussions in enhancing STEM outcomes and interpersonal growth.

These findings are consistent with national studies (Cholis & Dwi, 2020; Shofiyah et al., 2022) which affirm that collaboration in STEM improves both cognitive and affective learning dimensions.

Siekmann and Korbel (2016), through an extensive review of literature, argue that STEM skills should be conceptualized not only as technical and cognitive, but also as socio-emotional competencies, including teamwork, adaptability, and leadership. Their synthesis underlines the necessity of a holistic STEM education model, linking academic mastery with workforce preparedness.

Aligned with these global and national perspectives, Rarastika et al. (2025) demonstrate that integrating STEM into school-level mathematics instruction enhances students' critical and systemic thinking, creativity, and communication. These findings affirm the relevance of STEM-based learning in supporting the objectives of Indonesia's Merdeka Curriculum, which emphasizes active, contextualized, and collaborative educational practices. Additional findings also emphasize the importance of hands-on, interdisciplinary, and practice-based learning models. As highlighted by Trina and Burrows (2022), authentic STEM projects involving real-world inquiry and team-based problem solving allow students to step outside their academic comfort zones. Such models strengthen not only content mastery but also the development of interpersonal competencies essential in STEM-related careers.

Moreover, the synthesis by Siekmann and Korbel (2016) emphasizes that STEM competencies should be addressed across education levels—from primary through tertiary—encompassing foundational literacy, advanced cognitive skills, and socio-emotional dimensions. The inclusion of vocational education (VET) as part of the STEM ecosystem highlights how collaborative learning prepares students for future workforce demands beyond conventional academic settings. Kilty and Burrows (2022) also note that integrated STEM education benefits from the absence of hierarchical leadership in teams, allowing organic role development and equitable participation. Their findings suggest that project-based learning, when properly scaffolded, naturally cultivates leadership, accountability, and creativity within student teams.

In support of these strategies, initiatives such as teacher training by professional science organizations, like the Physical Society of Indonesia, play a crucial role in equipping educators with the pedagogical tools necessary to implement STEM-based learning effectively. Through these efforts, schools like MAN Pinrang have made significant strides in aligning their instructional practices with national priorities for 21st-century education. Therefore, this study seeks to examine students' collaboration skills within physics learning activities based on the STEM approach. The expected outcome is to provide insights into the effectiveness of collaborative STEM pedagogy in achieving the broader aims of quality education and future-ready skills development.

## II. METHOD

This research employed a descriptive qualitative approach using an ex-post facto design. Descriptive research is intended to investigate conditions or phenomena as they naturally occur, without manipulation or intervention by the researcher. According to Consuelo (2006), descriptive studies are designed to collect factual information about current conditions. The ex-post facto design, in particular, is used to examine variables or events that have already occurred, making it suitable for analyzing student behavior without implementing treatment. The study was conducted at MAN Pinrang, located in Jl. Bulu Pakoro, Paleteang District, Pinrang Regency, South Sulawesi, during the odd semester of the 2023/2024 academic year, specifically between September and October 2023**.**

The population of the study consisted of all students enrolled at MAN Pinrang, totaling approximately 1,050 students across three grade levels. From this population, a sample of 32 students was selected using simple random sampling to ensure equal opportunity for all members of the population to be included.

The primary instrument for data collection was a student response questionnaire designed to measure collaborative skills. The questionnaire consisted of 25 items based on five key indicators of collaboration: active contribution, productivity, responsibility, flexibility, and mutual respect. The items were developed using a Likert scale and underwent validation through expert review and item analysis procedures.

Data collection techniques included both questionnaires and interviews.

- The questionnaire was administered to assess students' self-perceived collaboration skills.
- The interview was conducted with a physics teacher to gather contextual insights and verify the classroom conditions related to collaborative learning implementation.

The data collection procedure was carried out in three stages:

1. Preparation Stage: Development and validation of the questionnaire instrument.
2. Implementation Stage: Coordination with physics teachers and school administration, followed by the distribution of the questionnaire to the selected students.
3. Final Stage: Data analysis using SPSS and the compilation of research findings and conclusions.

Data were analyzed using descriptive statistical techniques, including mean, maximum and minimum scores, and standard deviation, following the formulas provided by Riduwan (2016).

average score $\bar{X} = \frac{\sum f x_i}{n}$. …. (1)

Standar deviation

$$S = \sqrt{\frac{n\sum f x_i^2 - (\sum f x_i)^2}{n(n-1)}} \text{ ……. (2)}$$

## III. RESULT AND DISCUSSION

To measure students' collaboration skills, a questionnaire was administered. Five indicators were used in the assessment: active contribution, productive work, responsibility, flexibility, and respect for others. All paragraphs must be indented.

### A. Result

After the data analysis was conducted, the results were categorized based on the following standard criteria:

| *Number* | *Criteria* | *Percentage (%)* |
|---|---|---|
| 1 | Very High | 81- 100 |
| 2 | High | 61- 80 |
| 3 | Moderate | 41- 60 |
| 4 | Low | 21- 40 |
| 5 | Very Low | 0 – 20 |

The results obtained after analyzing the questionnaire for each indicator are as follows:

| **Description** | **Score** | | | | |
|---|---|---|---|---|---|
| | **Indicator 1** | **Indicator 1** | **Indicator 1** | **Indicator 1** | **Indicator 1** |
| **Mean** | 15,5 | 15 | 16,40625 | 16,34375 | 15,71875 |
| **Mean %** | 77,5 | 75 | 82,03125 | 81,71875 | 78,59375 |
| **Maximum Score** | 20 | 20 | 20 | 20 | 20 |
| **Minimum Score** | 5 | 5 | 5 | 5 | 5 |

### B. Discussion

This study began with preliminary observations of the research subjects. Based on interviews with both teachers and students, it was found that physics teachers at MAN Pinrang had previously received training on STEM-based learning methods, delivered by the Physical Society of Indonesia as part of a community engagement program in 2022. This research was conducted as a follow-up to the implementation of that outreach initiative. The next phase involved preparation, which included the development of research instruments and lesson materials. The instrument consisted of 25 questionnaire items designed around five indicators of collaboration: active contribution, productive work, responsibility, flexibility, and respect for others.

Following the preparation phase, the research continued with data collection by distributing the questionnaire to 32 student participants. The questionnaire aimed to assess students' collaboration skills within the context of physics learning using a STEM approach. Once the responses were collected, the data were analyzed based on each indicator.

The analysis showed that the first indicator (active contribution) had an average percentage score of 77.5%, which, according to Table 4.3, falls within the high category. The second indicator (productive work) scored 75%, also classified as high. The third indicator (responsibility) recorded an average percentage of 82.03%, placing it in the very high category. Similarly, the fourth indicator (flexibility) scored 81.72%, which is also considered very high. Lastly, the fifth indicator (respect for others) obtained an average of 78.59%, again falling into the high category.

Overall, the average percentage scores for each indicator indicate that the students' collaboration skills are generally in the **high to very high** range. This suggests that most students demonstrated effective collaboration during physics learning activities involving the STEM approach. These results show that collaboration is not only taking place but has become embedded in students' learning behaviors when STEM is implemented meaningfully.

These findings are consistent with previous research that emphasizes the positive impact of STEM-based learning on students' collaboration and interpersonal skills. For instance, a study by Cholis and Dwi (2020) demonstrated that students' collaboration skills improved significantly after participating in STEM-integrated learning activities in physics. Similarly, Shofiyah et al. (2022) found a strong correlation between collaboration and cognitive learning outcomes in STEM education. The current study reinforces these findings, showing that collaboration in STEM is not incidental, but an integral outcome of its design—one that fosters shared responsibility, active engagement, and mutual support.

Furthermore, this study supports the claim by Ahmed et al. (2024) that collaborative behavior can be cultivated through purposeful instructional design, particularly when learners are engaged in real-world problem-solving tasks. The observed high scores across all indicators suggest that students were not only able to function well in groups but were also developing essential 21st-century competencies. This is in line with the conclusions of Kilty and Burrows (2022), who noted that authentic STEM projects involving interdisciplinary teamwork foster stronger interpersonal connections, especially when students are encouraged to manage their roles organically.

Another relevant comparison can be drawn from the study by Nikiforos and Kolyvas (2020), which highlighted the role of educational robotics and teamwork in creating engaging STEM environments. Like the current study, their findings emphasized that collaborative learning environments stimulate student motivation and promote mutual accountability. The high scores in responsibility and respect for others in this study align with such perspectives, suggesting that collaborative STEM learning has both academic and socio-emotional benefits.

Moreover, this research aligns with national education priorities, particularly the goals of the **Merdeka Curriculum**, which encourages active learning, teamwork, and contextual application of knowledge. The findings here provide empirical evidence that the implementation of STEM-based learning not only supports curriculum expectations but also nurtures collaborative competencies in physics classrooms. In summary, the high levels of collaboration demonstrated by students indicate the effectiveness of STEM as both a pedagogical approach and a tool for character development. As this study is a direct continuation of a prior professional development program for teachers, it also highlights the value of sustained teacher training and follow-up research in evaluating the real impact of such initiatives on student learning.

## IV. CONCLUSION

Based on the analysis of the questionnaire results, it was found that the average percentage score for each indicator ranged from 75% to 83%, which falls within the high to very high category. These indicators include active contribution, productive work, responsibility, flexibility, and respect for others. Therefore, it can be concluded that students at MAN Pinrang demonstrate strong collaboration skills during physics learning that applies the STEM approach.

These findings suggest that STEM-based learning has a positive influence on students' ability to work effectively in teams, promoting shared responsibility and meaningful engagement. The collaborative skills shown by the students align well with the demands of 21st-century education, particularly in developing interpersonal competencies alongside academic achievement.

Implications of this study point to the importance of integrating STEM approaches into science teaching practices more consistently. The high level of collaboration observed indicates that project-based, interdisciplinary learning environments help foster both cognitive and socio-emotional growth among students. For educators, this underscores the need to continuously design learning activities that not only focus on content mastery but also cultivate soft skills such as communication, adaptability, and teamwork.

It is recommended that similar training and follow-up studies be conducted in other schools to evaluate the broader impact of STEM-based instruction. Additionally, ongoing support and professional development for teachers are essential to ensure they are equipped with the tools and strategies needed to facilitate collaborative learning environments effectively.

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