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STUDENTS' SCIENTIFIC COMMUNICATION SKILLS IN STEM ROBOTICS LEARNING THROUGH TRANSCRIPT-BASED LESSON ANALYSIS (TBLA)

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Abstract :

This study aims to analyze the scientific communication skills of junior high school students who participate in robotics extracurricular activities through STEM-based learning with the Transcript-Based Lesson Analysis (TBLA) approach. The research was conducted at Nurul Ilmi 1 Integrated Islamic Junior High School, Jambi City, involving four groups of robotics extracurricular students. Each group is involved in the robot creation and testing project, and the interactions between group members during the activity are recorded, transcribed and analyzed using TBLA instruments. The analysis was carried out in a descriptive quantitative manner by calculating the frequency of the occurrence of six indicators of scientific communication, which were then converted into percentages. This process is done with the help of an excel application. Preliminary results show that the most dominant indicators are the ability to convey work verbally and the use of simple scientific terms, while the indicator asking about how robots work appears the least. These results provide an overview of students' scientific communication tendencies in the context of robotics activities, as well as provide a basis for the development of STEM learning models that can improve students' scientific communication skills through non-formal approaches.

Keywords: Scientific Communication, STEM, Robotics, Lesson Study, TBLA

Abstrak:

Penelitian ini bertujuan untuk menganalisis kemampuan komunikasi ilmiah siswa SMP yang mengikuti kegiatan ekstrakurikuler robotika melalui pembelajaran berbasis STEM dengan pendekatan *Transcript-Based Lesson Analysis* (TBLA). Penelitian dilakukan di SMP Islam Terpadu Nurul Ilmi 1 Kota Jambi dengan melibatkan empat kelompok siswa anggota ekstrakurikuler robotika. Setiap kelompok terlibat dalam proyek pembuatan dan pengujian robot, dan interaksi antaranggota kelompok selama kegiatan direkam, ditranskrip, dan dianalisis menggunakan instrumen TBLA. Analisis dilakukan secara kuantitatif deskriptif dengan menghitung frekuensi kemunculan enam indikator komunikasi ilmiah, yang kemudian dikonversi ke dalam bentuk persentase. Proses ini dilakukan berbantu dengan aplikasi excel. Hasil awal menunjukkan bahwa indikator yang paling dominan adalah kemampuan menyampaikan hasil kerja secara lisan dan penggunaan istilah ilmiah sederhana, sedangkan indikator bertanya tentang cara kerja robot paling jarang muncul. Hasil ini memberikan gambaran mengenai kecenderungan komunikasi ilmiah siswa dalam konteks kegiatan robotika, serta memberikan dasar bagi pengembangan model pembelajaran STEM yang dapat meningkatkan keterampilan komunikasi ilmiah siswa melalui pendekatan non-formal.

Kata kunci: Komunikasi Ilmiah, STEM, Robotika, Lesson Study, TBLA

INTRODUCTION

The rapid advancement of science and technology in the era of the Industrial Revolution 4.0 and Society 5.0 demands that the younger generation possess 21st-century skills, which include critical thinking, creativity, collaboration, and communication (4C)) (Hindun et al., 2022; Muamala & Wulandari, 2024). In the context of science education, scientific communication is a key competency that enables students to convey their ideas, arguments, and findings logically, evidence-based, and comprehensibly (Aini, 2023). This skill is particularly crucial in project-based learning activities, where students work collaboratively in groups to design, test, and present their work. In this study, the researcher acted as an observer in Lesson Study activities, systematically recording student interactions for further analysis.

The Science, Technology, Engineering, and Mathematics (STEM) approach is considered an effective strategy for developing students' 4C skills. STEM integrates multiple disciplines in solving real-life problems, encouraging students to think creatively, collaborate, and communicate their ideas (Ouyang & Xu, 2024). This integration is even more impactful when combined with problem-based learning designs, as it allows students to actively engage in contextual, inquiry-driven activities that connect academic concepts to local wisdom and everyday life (Siahaan et al., 2025).One of the popular media used in STEM implementation is educational robotics, which combines mechanical, electronic, and programming aspects. Within the Lesson Study framework, learning is conducted collaboratively between teachers and observers to design, implement, and reflect on the learning process. This model allows observers, such as the researcher in this study, to authentically document student interactions during learning (Susanti, 2023). Such documentation can be further enhanced through methods like Transcript-Based Lesson Analysis (TBLA), which provides detailed, evidence-based insights into specific learning aspects, including scientific communication skills (Sembiring et al., 2025).In this context, the researcher observed how students interacted during the robot design and testing process, recording communication patterns and collaboration within groups (Arafat et al., 2024; Susanti & Aprian, 2022).

Previous studies have shown that student involvement in robotics learning can enhance problem-solving skills, technological literacy, and creativity (Aristawati & Budiyanto, 2017; Prity Choudhary & Pooja Potdar, 2023). However, most robotics research in STEM education has focused on understanding science concepts and technical skills such as coding or robot design (Asri, 2018). The aspect of students' scientific communication skills including the ability to ask questions, express opinions, provide feedback, and present results has rarely been explored in depth. In this study, data were collected using Transcript-Based Lesson Analysis (TBLA), in which the researcher, as an observer, recorded and transcribed student interactions during activities to analyze the frequency based on scientific communication indicators (Irvan Irvani & Agus, 2024; Sinaga et al., 2022; Susanti et al., 2021).

Most existing TBLA studies are qualitative in nature and conducted on teachers or pre-service teachers (Ningsi et al., 2023; Qomariyah et al., 2023). Quantitative TBLA research focusing on junior high school students, particularly in robotics extracurricular activities, remains scarce. In fact, non-formal learning such as extracurricular programs can provide a more flexible space for students to naturally develop their scientific communication skills through group interactions (Muamala & Wulandari, 2024).

Based on the literature review, several research gaps underlie this study. First, although many studies have shown that robotics- and STEM-based learning can improve critical thinking, creativity, problem-solving, and teamwork skills, few have specifically analyzed the development of students' scientific communication skills using TBLA (Asri, 2018). Second, most research has emphasized understanding science concepts and robotics technical skills, while the scientific communication aspect has been less discussed. Third, the integration of STEM robotics learning modules with TBLA as an instrument for evaluating students' scientific communication skills remains very limited. Fourth, studies on the effectiveness of TBLA in the junior high school context, especially in robotics extracurricular activities, are almost non-existent. Fifth, most TBLA studies focus on teachers or pre-service teachers, while the use of quantitative TBLA to map scientific communication indicators among junior high school students is still minimal. In this study, the researcher actively served as an observer in Lesson Study to document student interactions in detail through transcripts, allowing a measurable and objective mapping of scientific communication profiles.

In line with these research gaps, the aim of this study is to analyze the scientific communication skills of junior high school students participating in STEM-based robotics extracurricular activities using TBLA within the Lesson Study framework. The researcher focuses on identifying and counting the frequency of six predetermined scientific communication indicators to obtain a quantitative overview of communication patterns in learning. The results of this study are expected to contribute to the development of STEM learning strategies that are more communicative, collaborative, and evidence-based

METHODS

Research Design

This study employed a descriptive quantitative approach to describe students' scientific communication skills based on the frequency of indicators identified through Transcript-Based Lesson Analysis (TBLA). This approach allows data to be presented in numerical and percentage form, facilitating the analysis of communication patterns (Yusuf, 2017). The researcher acted as an observer within the framework of Lesson Study, focusing on recording and documenting students' interactions authentically during STEM-based robotics learning. This position enabled the researcher to observe scientific communication behaviors without interfering with the learning process.

Procedure

The study was conducted using the Lesson Study cycle, which consists of three main stages: planning (plan), implementation (do), and reflection (see) (Pulsande et al., 2021). During the *plan* stage, the researcher and teacher collaboratively designed the STEM-based robotics lesson. In the *do* stage, the lesson was implemented, and the researcher, as an observer, recorded all student interactions. In the *see* stage, the recorded data were analyzed together with the teacher to identify the occurrence of scientific communication indicators.

The TBLA process in this study involved:

1. Recording videos of the STEM robotics learning process during the *do* stage.
2. Fully transcribing students' interactions into TBLA table format.
3. Identifying students' statements according to the six scientific communication indicators.
4. Calculating the frequency of each indicator's occurrence.

Participants / Sample

The research subjects were 30 male students from SMP IT Nurul Ilmi 1 who participated in an extracurricular robotics program. The students were divided into four groups with varying numbers of members. The extracurricular setting was chosen because it provides students with flexible opportunities to develop 21st-century skills, including scientific communication, through project-based activities (Muamala & Wulandari, 2024)

Instruments

The research instrument consisted of a TBLA observation sheet containing six indicators of scientific communication skills:

1. Asking about the working mechanism or function of robot components.
2. Explaining ideas to group members.
3. Responding to peers' ideas with reasons or experimental evidence.
4. Demonstrating experimental or trial results of the robot.
5. Using simple scientific terms.
6. Verbally presenting the group's work to peers or the teacher.

These indicators were adapted from the scientific communication assessment framework in science learning (Mahmud et al., 2023).

Data Analysis

Data were analyzed using descriptive quantitative techniques by calculating the percentage of each indicator's occurrence using the formula:

$$\text{Percentage} = \frac{\text{Number of occurrences of the indicator}}{\text{Total student statements}} \times 100\%$$

This percentage method was chosen because it can provide a clear depiction of the proportion of each scientific communication indicator that emerged during the learning process (Sudijono, 2018).

RESULTS AND DISCUSSION

Based on the results of the research carried out, several results were obtained.The results and discussion for each data set are presented as follows. all participants in this study were male students who joined the robotics extracurricular activities at SMP IT Nurul Ilmi 1. This explains that the findings are that male students are more interested in robotics extracurriculars than female students. This is in line with the opinion of Anjos et al (2024), technological developments provide equal opportunities for both genders to participate in robotics activities but male learners are more interested in this

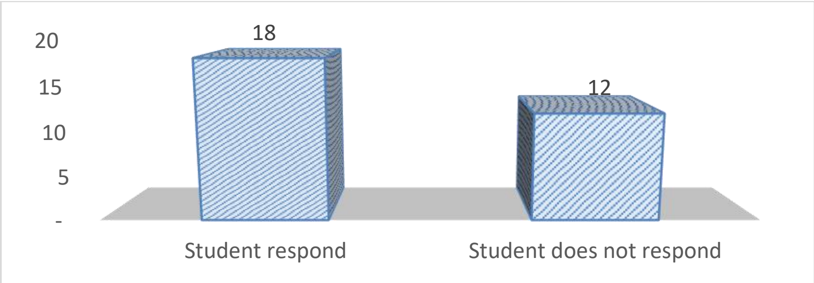

Figure 2. Number of student responses

Figure 2 about from the total of 30 students, 18 students (60%) gave active responses recorded in the Transcript-Based Lesson Analysis (TBLA). Active responses included verbal statements related to the STEM-based robotics learning activities, in the form of questions, ideas, or responses to peers' ideas. This finding shows that not all students were verbally engaged during the learning process, which may be influenced by internal factors such as self-confidence and external factors such as the dominance of certain group members (Amintarti et al., 2020). The presence of students who were silent or passive during collaborative learning sessions has also been noted in previous studies, indicating the importance of equitable participation in group tasks (Demetroulis et al., 2023).

Table 1. Distribution of Scientific Communication Indicators

No	Indicator	percentage
1	Asking about how a robot component works or its function	4,03%
2	Explaining ideas to group members	16,11%
3	Responding to peers' ideas with reasons or practical evidence	14,20%
4	Showing experimental or trial results directly	3,99%
5	Using simple scientific terms	5,15%
6	Presenting group work verbally to peers or the teacher	1,59%

The highest percentage was found in explaining ideas (16.11%), followed by responding to peers' ideas (14.20%). This pattern suggests that students were more comfortable providing explanations or feedback than asking questions or formally presenting results. Similar patterns were identified in previous studies, where questioning skills among middle school students were less developed compared to their ability to respond or explain (Cici Mayani et al., 2023; Fuadah et al., 2017).

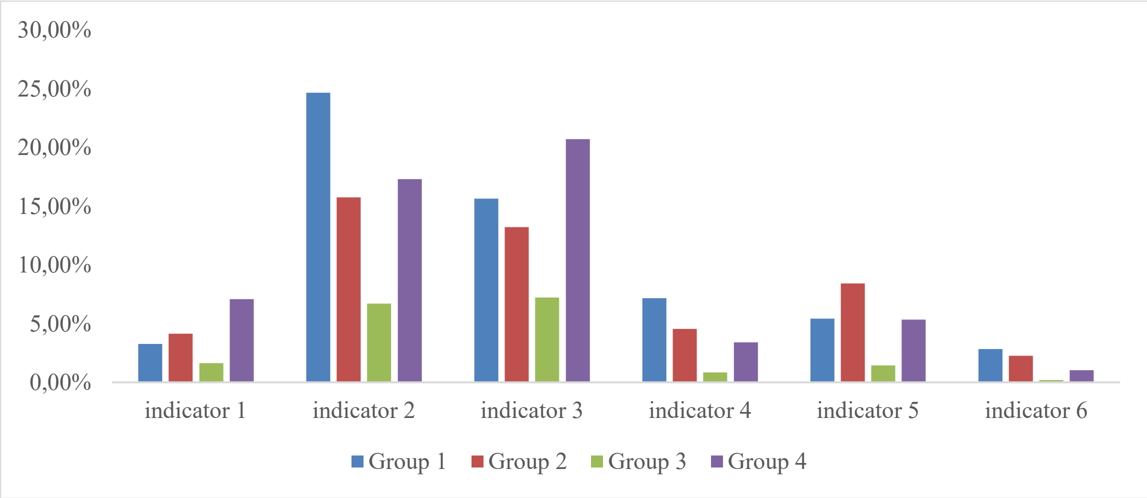

Figure 3. Comparison of Indicator Percentages by Group

The comparative analysis of each scientific communication indicator across the four student groups revealed clear variations in achievement patterns, suggesting that each group demonstrated different strengths and tendencies in their communication skills during the robotics-based STEM learning process. This difference is consistent with the findings of Pulsande et al (2021), who emphasized that variation in indicator achievement in TBLA-based Lesson Study is influenced by the dynamics of group interaction, the distribution of speaking turns, and the extent to which students are encouraged to verbalize their thoughts.

For Indicator 1 (Asking about how components work), the highest percentage was recorded in Group 4 (7.08%), indicating a higher degree of curiosity and willingness to seek clarification compared to other groups. According to Amintarti et al (2020), the act of asking questions in a TBLA framework is an essential form of active engagement, as it triggers deeper cognitive processing and helps clarify conceptual understanding. This suggests that Group 4's members were relatively more confident in initiating inquiry during the lesson.

In Indicator 2 (Explaining ideas to peers), Group 1 achieved the highest percentage (24.67%). This dominance implies that members of Group 1 were more proactive in articulating their thoughts, possibly due to strong leadership roles or balanced distribution of participation. Wikanengsih & Rostikawati (2024), note that clear verbal explanations in collaborative settings not only enhance individual understanding but also strengthen group cohesion. This reinforces the notion that the social dynamics within Group 1 may have been more supportive of idea-sharing behaviors.

For Indicator 3 (Responding to peers with evidence), Group 4 again scored the highest (20.72%), showing that this group engaged more in interactive dialogue and critical exchange. Such patterns align with Cici Mayani et al (2023), who found that the ability to respond using evidence reflects students' readiness to integrate experimental results into their reasoning, an important marker of scientific communication. The high score in this indicator indicates that Group 4's discussion environment may have been more argumentatively rich and evidence-oriented.

In Indicator 4 (Demonstrating experimental results), Group 1 achieved the highest proportion (7.17%). The act of demonstrating results is a critical stage in the communication process, as it allows for visual verification of claims and encourages further discussion. Aristianti et al (2018), highlight that performance-based demonstrations in science classes serve as both communication tools and assessment opportunities, enabling peers and instructors to directly evaluate the accuracy of work.

For Indicator 5 (Using simple scientific terms), Group 2 reached the highest percentage (8.41%). This suggests that the group's members had relatively stronger mastery of basic scientific vocabulary, which is consistent with the observation of Amintarti et al (2020), that effective science communication often relies on appropriate and accurate terminology to maintain clarity and precision in peer discussions.

Finally, in Indicator 6 (Reporting to the teacher or class), Group 1 recorded the highest score (2.83%). While the percentage is relatively low compared to other indicators, it still reflects the group's tendency to take the role of spokesperson in formal classroom reporting situations. According to

Pulsande et al (2021), such roles are often shaped by group norms and individual willingness to represent the collective output to a wider audience.

Overall, the comparative data suggest that no single group dominated all aspects of scientific communication, but rather, each demonstrated particular strengths that could be leveraged in future collaborative learning activities. These variations highlight the importance of structuring group work in such a way that all communication indicators are evenly encouraged, in line with Wikanengsih & Rostikawati (2024), who advocate for deliberate facilitation strategies to balance participation and skill development across collaborative teams.

CONCLUSION AND SUGGESTION

This study concludes that STEM-based robotics learning implemented through Lesson Study with Transcript-Based Lesson Analysis (TBLA) fosters various forms of students' scientific communication, although verbal participation is not evenly distributed among all participants. The findings indicate that students tend to explain and respond to ideas more than asking questions or formally presenting results. Differences between groups suggest that internal dynamics and role distribution affect communication skills. Therefore, it is recommended that teachers promote equal participation, provide more opportunities for questioning, and consistently apply TBLA to monitor and improve interaction patterns in STEM and robotics learning.

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