*26 (1), 2025, 499-511*

**Jurnal Pendidikan MIPA**

e-ISSN: 2685-5488 | p-ISSN: 1411-2531

http://jurnal.fkip.unila.ac.id/index.php/jpmipa/

# STEM-SDGs Integration to Improve Scientific Communication Skills in Junior High School Science Learning

**Norma Puspa Rini, Pramudya Dwi Aristya Putra*, & Nur Ahmad**

Departement of Science Education, University of Jember, Indonesia

**Abstract:** Scientific communication is defined as verbal communication that is related to investigation. Science learning has an important part in the scientific communication skills that learners must have, which involves a scientific approach whose stages include observing, questioning, collecting data, evaluating data, and expressing conclusions. Scientific communication has an important role to be mastered by learners to succeed in science disciplines. This study aims to identify STEM-SDGs-based Students' Worksheets used by students in supporting scientific communication skills on temperature, heat, and expansion material and analyze the scientific communication skills of junior high school students in discussing SDGs issues related to temperature, heat, and expansion. The method in this research uses a qualitative approach with a single case study research type. This research was conducted at MTSN 2 Jember in the odd semester of the 2024/2025 school year. The results showed that the application of STEM-SDGs-based Students' Worksheets played a role in improving students' scientific communication skills. This is because the STEM-SDGs-based Students' Worksheets has been prepared by 25% to support each indicator. The STEM approach that integrates various disciplines encourages students to actively participate and discuss, thus strengthening their understanding of complex scientific concepts. Based on the analysis of students' scientific communication skills after using the STEM-SDGs-based Students' Worksheets, it was found that the highest student condition was in the fourth indicator, namely representation form (86%) with a very good category. While the lowest student condition in the third indicator, namely the use of scientific terms (code), which tends to be low with a deficient category (72%). The interview results show that students understand concepts related to SDGs and can explain scientific phenomena, but still use colloquial language rather than appropriate scientific terms.

**Keywords:** scientific communication, STEM, SDGs, temperature, heat, expansion.

## ▪ INTRODUCTION

Science learning has an important part in the scientific communication skills that students must have, which involves a scientific approach whose stages include observing, questioning, collecting data, evaluating data, and expressing conclusions (Ika, 2018). Scientific communication is defined as verbal communication that is related to investigation. Scientific communication has an important role to be mastered by learners to succeed in science disciplines (Afkarina et al., 2024). Scientific communication skills are now essential for the effective dissemination of scientific knowledge and research findings to a variety of audiences, including peers, policy makers, the media, and the general public (Taufiq and Rokhman, 2020).

Some schools pay less attention to students' abilities in scientific communication, so students have difficulty in giving their opinions (Kurniawan et al., 2020). Factors that influence the low scientific communication of students are the ineffective teaching and learning process using conventional methods, teachers pay less attention to how to communicate with students, the environment around students, lack of motivation (Rianigsih et al., 2019). Based on the results of research conducted by Afkarina et al.,

Pramudya Dwi Aristya Putra
*Email: pramudya@fkip.unej.ac.id

DOI: http://dx.doi.org/10.23960/jpmipa/v26i1.pp499-511
Received: 24 February 2025
Accepted: 26 March 2025
Published: 05 May 2025

(2024) entitled "Analysis of Scientific Communication Skills of High School Students through STEM-SDGs Learning on Global Warming Material" states that during the learning process, students' scientific communication skills tend to increase, but the indicators of the use of scientific language terms tend to be stable and there is no increase (Afkarina et al., 2024).

The STEM (Science, Technology, Engineering, and Mathematics) approach can be said to be a global movement in educational practice known as STEM-based learning incorporating many integration patterns to build human resources that meet the competency needs of the 21st century. One type of education that fits the Indonesian curriculum is STEM-based learning. The STEM approach is a learning approach in natural science, technology, engineering, mathematics united in a teaching and learning process that is oriented towards problem solving for scientific activities (Handayani, 2020).

STEM in Junior High School (SMP) aims to develop STEM literate learners. Learners in STEM learning at the junior high school level are required to provide challenges in performing authentic engineering tasks to complement the science teaching and learning process with project activities that integrate science, engineering, technology, and mathematics (Zulaiha and Kusuma, 2020). STEM learning objectives also support the principles of the Sustainable Development Goals (SDGs) in goal 4, which is to provide high quality learning. Learning that requires active student participation is considered quality learning (Ardwiyanti et al., 2021).

According to Ismail and Wahidin (2022), students' scientific communication skills can be taught and improved through the STEM approach. Students who master STEM-based science subjects are expected to have various abilities that can help in addressing global issues, including science literacy and higher order thinking skills. The material of temperature, heat, and expansion has complex characteristics, so it can be a solution in developing learning tools based on the STEM-SDGs approach (Sakti et al., 2022). Based on the description above, the purpose of this study is to determine the STEM-SDGs-based Students' Worksheets used by students in supporting scientific communication skills and supporting the SDGs program on temperature, heat, and expansion material, and to determine the scientific communication skills of junior high school students in discussing SDGs issues related to temperature, heat, and expansion.

A review of previous studies shows that the STEM (Science, Technology, Engineering, and Mathematics) approach consistently has a positive influence in improving students' scientific communication skills. For example, research by Afkarina et al. (2024) revealed that STEM-SDGs-based learning on global warming material can improve students' scientific communication skills, although the indicator of using scientific terms still shows stagnation. Another study by Ismail and Wahidin (2022) confirmed that the STEM approach can develop students' higher-order thinking skills and science literacy, which are important in dealing with global issues. However, some studies also noted obstacles such as the lack of attention to mastery of scientific terms and the formulation of appropriate scientific topics by students (Kurniawan et al., 2020; Rianigsih et al., 2019).

The novelty of this research lies in its focus on integrating STEM-SDGs-based Students' Worksheets in learning temperature, heat, and expansion materials at the junior high school level with in-depth analysis of each indicator of scientific communication

skills. This research fills a gap that has not been widely explored, namely how STEM-SDGs-based Students' Worksheets can specifically influence the ability to represent scientific evidence and use scientific terms appropriately. In addition, this research also makes a new contribution by evaluating the effectiveness of LKPDs in

Research Questions

1. How is the STEM-SDGs-based Students' Worksheets used by students in supporting scientific communication skills on temperature, heat, and expansion material?
2. How are the scientific communication skills of junior high school students in discussing SDGs issues related to temperature, heat, and expansion?

## ▪ METHOD

The method in this study uses a qualitative approach with a single case study type of research which focuses on one type of case or one phenomenon only (Putra et al, 2023). Primary data collection was carried out by interviewing students and also observation during the process of learning activities. Secondary data that supports this research is in the form of journals and books. The data collection process was carried out during the learning process by working on the STEM-SDGs-based Students' Worksheets and after the learning process by using interviews related to scientific communication.

This research was conducted at MTS Negeri 2 Jember which is located on Merak Street No.11, Puring, Slawu, Patrang District, Jember Regency, East Java 68116. The research was conducted in the odd semester learning process of the 2024/2025 school year. The informants in this study were students of class VII C MTs Negeri 2 Jember.

The informants in this study were students of class VII C MTs Negeri 2 Jember. Informants were determined through purposive sampling technique with certain considerations that are able to provide important information to researchers. Informants in one class consisted of 29 students, but the research sample amounted to 8 students. Using the criteria of student scores above the Minimum Completeness Criteria (KKM).

The method in this study uses a qualitative approach with a single case study research type, which focuses on one type of case or one phenomenon only (Putra et al, 2021). Primary data collection was carried out by interviewing students and also observation during the learning activity process. Secondary data that supports this research are journals and books. The data collection process was carried out during the learning process by working on the STEM-SDGs-based LKPD and after the learning process by using interviews related to scientific communication. The data collection techniques and instruments used in this study are:

1. Observation, observation in this study was carried out during the learning process by working on tasks and experiments by students contained in the STEM-SDGs-based LKPD. The learning process that was observed was the scientific performance and engineering performance carried out by students during learning activities on temperature, heat, and expansion materials using an observation sheet. To facilitate the description related to student observation results and LKPD assessment per group, calculations are carried out using a Likert scale (Sugiyono, 2016) in categorizing each indicator of students' scientific communication skills.
2. Interview, interviews were conducted with 7th grade science teachers before the research to find out whether or not MTS Negeri 2 Jember had used STEM-SDGs-

based learning media. Interviews were conducted semi-structured, namely using interview guidelines to the students concerned, namely 8 students who were used as research samples according to the criteria for scores above the Minimum Completeness Criteria (KKM) after 8 meetings. The type of interview is open to the respondent's response and answer. Interviews were conducted using an interview guideline sheet in order to obtain in-depth and broad information related to the identification of scientific communication of junior high school students using STEM-SDGs-based LKPD after the process of learning activities in the classroom.

3. Documentation, Documentation in the form of names of students who became subjects in the study, and learning activities in the form of recordings during the interview process, learning videos, and photos during learning.

The data analysis method in qualitative research consists of 4 steps, namely data collection, data reduction, data presentation, and conclusion drawing (Miles & Huberman, 1984: 12). The data analysis process is as follows:

1. Data Collection: The process of collecting data on scientific communication skills is obtained through observation, interviews, STEM-SDGs-based LKPD, and documentation. The data will be analyzed and processed into text data.
2. Data Reduction: Data reduction carried out by researchers is selecting data in accordance with the research objectives and discarding inappropriate data. Data reduction aims to process the data obtained more systematically.
3. Data Presentation: Data presentation is data that has been in accordance with the research objectives presented in the form of tables, figures, descriptions, or relationships between categories systematically. After that, the data verification process is carried out through triangulation techniques.

d. Conclusion Drawing: Drawing conclusions, namely at this stage the researcher presents verified data from the triangulation technique to provide answers to the formulation of research problems. Analysis is used with cross sectional (collected at one point in time or a certain year) frequency calculations that arise in compiling scientific communication from student statements.

## ▪ RESULT AND DISSCUSSION

### STEM-SDGs-based LKPDs Used by Students to Support Student Scientific Communication

The process of activities carried out by students as a source in research as well as participation in activities carried out by students. The learning process is carried out with the STEM learning model on temperature, heat, and expansion material through STEM-SDGs-based Students' Worksheets as a form of student participation. Students' scientific communication activities in learning such as compiling scientific topics, skills in conveying topics, using scientific language terms, and representing the findings of scientific evidence from the delivery of material and through working on LKPDs are sources of data in research observed by researchers.

**Table 1.** Data on students' worksheets assessment results of students in groups

| Indicators of Scientific Communication | Total Activity | Presentage | Description |
|---|---|---|---|
| Factual Content | 3 | 50% | Poor |

| | | | |
|---|---|---|---|
| Context | 3 | 50% | Poor |
| Code | 3 | 25% | Very Poor |
| Representation Form | 3 | 75% | Very Good |

Category description:
- Very Good: >75%
- Good: 50%-75%
- Poor: 25%-50%
  Very Poor: <25%

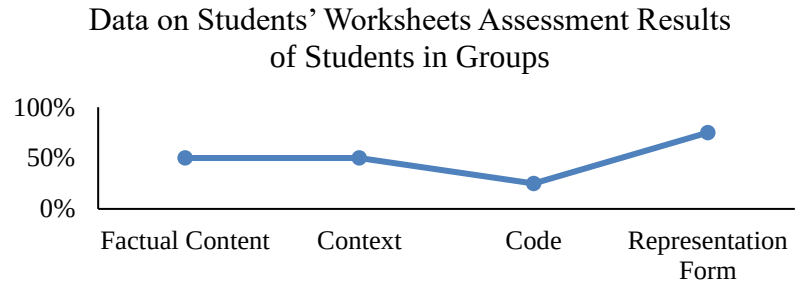


Table 4.1 shows the distribution of students' scientific communication skills in learning activities. The number of activities carried out when working on the STEM-SDGs-based Students' Worksheets has been set at 25% to support each indicator having 3 learning activities. From learning activities 1, 2, and 3, it can be seen that the highest indicator is representation form with an very good category (75%), while the lowest indicator is code with a poor category (25%).

The ability of students' scientific communication skills can be obtained by analyzing the results of students' answers in the STEM-SDGs-based Students' Worksheets used as teaching materials. Based on the data from the Students' Worksheets assessment results of students per group in Table 4.1, there are indicators of scientific communication skills that are still slightly low with the "less" category in the third indicator section, namely code. STEM-SDGs-based Students' Worksheets plays a role in improving students' scientific communication skills. This is because the STEM-SDGs-based Students' Worksheets has been prepared by 25% to support each indicator. The assessment of Students' Worksheets used by students is adjusted to the existence of scientific communication indicators and SDGs issues on temperature, heat, and expansion material.

The first indicator of scientific communication is to develop scientific topics (factual content) carried out by students based on the conditions of the SDGs issue, where in Table 4.2 the learning activity section 1 "Temperature" knows that an increase in the earth's temperature can trigger various natural disasters, this is related to one of the SDGs, namely energy efficiency, so in learning activity 2 "Caloric" students are asked to do a practicum to make a simple solar cooker, but in this first indicator students can only mention the purpose of the experiment, not linking it to the 7th SDGs. In learning activity 3 "Expansion" students are also asked to do an experiment, namely making a simple thermostat to save energy according to the 7th SDGs issue, students can only mention the 7th SDGs issue, namely energy efficiency, not writing the purpose of the experiment. So based on the activity of identifying and defining problems, it shows that students' ability

to formulate problems is low in learning activities 2 and 3, because students are still confused in formulating scientific topics appropriately. The STEM stage in this factual content indicator, namely define, helps the activities carried out by these students, at the define stage students are able to detail and clearly define the problems they will solve (Putra et al., 2021).

The second indicator of scientific communication skills is skills in conveying scientific topics, where in table 4.3 part of learning activity 1 "Temperature" students are able to connect the concept of increasing the earth's temperature with the real impacts that occur in the surrounding environment, such as natural disasters, but in learning activity 2 "Heat" students are able to explain how a simple solar cooker works, while learning activity 3 "Expansion" students are able to explain the phenomenon of expansion in a wire when heated such as the working principle of a simple thermostat. Based on this, students are able to explain their opinion by saving energy both fossil fuels and excessive use of electrical energy. In line with the research of Kurniawan et al., (2020) which states that scientific communication is one of the abilities that must be familiarized by students, scientific communication can be familiarized if students are always accustomed to expressing their opinions.

The third indicator of scientific communication skills is the use of scientific terms in the field of science, where the use of terms contained in Table 4.4 include: temperature, global warming, greenhouse gas emissions, water resources, heat, solar radiation, expansion, sensors, and energy efficiency. Based on the results of Aini's research (2023) stated that students' scientific communication skills can be seen in learning activities related to natural events or phenomena. Therefore, the use of scientific terms in learning can train students' scientific communication skills.

The fourth indicator of scientific communication skills is representative forms of scientific evidence. In Table 4.5 learning activity 1 "Temperature" students are able to categorize the degrees of Celsius, Fahrenheit, Reanur, and Kelvin temperatures and conclude that if the temperature of the three different waters has a different scale from the initial temperature. Whereas in learning activity 2 "Heat" it is found that students are able to calculate the amount of heat when heated and conclude that a simple solar stove can replace a gas stove, which can save the use of fossil fuels. Learning activity 3 "Expansion" found that students are able to compare the expansion data that occurs in the wire that increases when it is brought closer to the heat source and are able to conclude that the use of a simple thermostat is related to energy efficiency. In line with Munawaroh and Wahidin's research (2022) stated that through STEM learning, scientific communication skills on indicators of conveying representations of forms of scientific evidence findings can increase because students gain new experiences and abilities in overcoming a problem. With new insights and evidence findings, students' scientific communication skills can improve for the better.

It can be seen from the results of observations that have been made in the three learning activities (temperature, heat, and expansion) that students are more active when conducting practical experiments and presenting the results of experiments that have been carried out. Learning activity 1 "Temperature" is evidenced by conducting a simple experiment, namely measuring the temperature of three different waters (ordinary water, warm water, and hot water), and students are able to convert Celsius degree temperatures into Fahrenheit, Reamur, and Kelvin. Learning activity 2 "Heat" is also proven when

doing a simple experiment by making a simple solar cooker, and students can find out the heat transfer from sunlight to water when heated under the sun during the day, and students can calculate the amount of heat using the heat formula. In addition, in learning activity 3 it is also proven by a successful simple experiment, namely making a simple thermostat, then measuring the expansion of a wire when it is brought closer to a heat source, and students can measure expansion using the expansion formula. During these three learning activities, students are also able to present the results of their experiments and conclusions. The STEM-SDGs-based LKPD also supports the result that students can improve scientific communication.

**Students Scientific Communication Skills**

Based on the research that has been done, the results of students' scientific communication skills are obtained as the dependent variable in the study. While the variable in this study is the use of STEM-SDGs-based LKPDs on temperature, heat, and expansion materials. Indicators of students' scientific communication skills are the main data in this study, which include indicators of compiling scientific topics (factual content), skills in conveying scientific topics (context), using scientific language (code), and the form of scientific evidence findings (representation form). Supporting data were taken from the observation activities, where the observer observed and measured each indicator of students' scientific communication with the categories of Very Good (4), Good (3), Poor (2), and Very Poor (1). The observation data is presented in the following table:

**Tabel 6.** Data from observation of 29 students

1. Learning activity 1

| **Indicator of scientific communication** | **Total number of students (%)** | | | |
|---|---|---|---|---|
| | **VP** | **P** | **G** | **VG** |
| Factual Content | - | 10 | 90 | - |
| Context | - | 10 | 90 | - |
| Code | - | 10 | 90 | - |
| Representation Form | - | 3 | 14 | 83 |

2. Learning activity 2

| **Indicator of scientific communication** | **Total number of students (%)** | | | |
|---|---|---|---|---|
| | **VP** | **P** | **G** | **VG** |
| Factual Content | - | 10 | 90 | - |
| Context | - | 17 | 58 | 24 |
| Code | - | 72 | 3 | 24 |
| Representation Form | - | - | 14 | 86 |

3. Learning activity 3

| **Indicator of scientific communication** | **Total number of students (%)** | | | |
|---|---|---|---|---|
| | **VP** | **P** | **G** | **VG** |
| Factual Content | - | 10 | 90 | - |
| Context | - | 10 | 90 | - |
| Code | - | 10 | 90 | - |
| Representation Form | - | - | 14 | 86 |

Based on table 4.6, it appears that most of the scientific communication indicators are categorized as good, namely the indicator of compiling scientific topics in learning activities 1 to learning activities 3 has not changed, namely 90%. The indicator of skills in conveying topics in learning activity 1 is 90% good category, but in learning activity 2 it has decreased to a good category of 58%, and increased again in learning activity 3 which is a good category of 90%. The indicator of the use of scientific language in learning activity 1 is 90% in the good category, but in learning activity 2 it has decreased in the less category, namely 72%, and increased again in learning activity 3, namely in the good category, namely 90%. The last indicator, namely the form of scientific evidence findings in learning activity 1, namely 83% very good category, but in learning activity 2 and learning activity 3 experienced an increase in the very good category, namely 86%.

Analysis of table 4.4 shows a significant increase in students' scientific communication skills from learning activities 1 to 3. There was an increase in the percentage of students who achieved good (B) and very good (SB) criteria, especially in the indicators of skills in conveying scientific topics and using scientific language. In addition, students' ability to organize scientific topics was also maintained consistently, indicating good mastery from the beginning. These results indicate that the series of learning activities that have been carried out are effective in developing students' scientific communication skills. Students showed active involvement in discussions on SDGs issues, especially those related to temperature, heat and expansion. They are able to express opinions, ask questions, and provide relevant arguments based on the scientific information they have learned. These discussions often begin with the presentation of a problem, followed by data analysis and the development of solutions that are in line with the principles of the SDGs.

During the discussions, students tended to use appropriate scientific terms, although there were variations in their level of understanding. Some students showed good ability in using scientific terminology, while others still needed guidance to improve their use of the terms. This shows an improvement in their scientific communication skills, although there is still room for improvement. Group discussions provided opportunities for students to collaborate and share knowledge. They learn from each other and develop social skills and scientific communication through this interaction. Students who understand the concepts better often help their peers who are struggling, creating a supportive learning environment.

The interview was conducted at the eighth meeting, namely at the end of learning conducted by students as participants, after using learning media in the form of STEM-SDGs-based LKPD. The interview was conducted in depth to identify the scientific communication skills of junior high school students through STEM learning that students showed when answering interview questions.

The first indicator of scientific communication skills is factual content. Students can organize a good scientific topic as shown by the data from the interview transcript according to each indicator. However, based on the data obtained, students only briefly mention the meaning of SDGs (Sustainable Development Goals). The following is a transcript of students' answers to the question of what students know about SDGs.

"*If what I know from learning using the STEM-SDGs-based LKPD yesterday, SDGs stands for Sustainable Development Goals, which means sustainable development goals" (Factual Content)*.

The second question on the first indicator of scientific communication students are able to mention several types of SDGs that students know. The following are examples of interview transcripts of students' questions mentioning the kinds of SDGs they know.

"*There is the 7th SDG on clean and affordable energy, and the 13th SDG on climate change action" (Factual Content)*.

The second indicator of scientific communication skills is context. Students can define the meaning of learning materials, namely temperature, heat, and expansion. The following is a transcript of student answers to the question what do you know about temperature, heat, and expansion.

"*Temperature is the heat or coldness of an object. Heat is heat that moves from one object to another. Expansion is when an object becomes bigger when it is heated*." (Context)

The second question of the second indicator of scientific communication is context. Students can convey scientific topics well as shown by the data from the interview transcripts according to their respective indicators. Students can answer well based on the data obtained from the second question in this second indicator. The following is a transcript of student answers to the question of how an understanding of temperature, heat, and expansion can help in designing a more efficient energy system.

"*We can make good use of heat, for example by making solar cookers as a substitute for LPG gas stoves.*" (Context)

The third indicator of scientific communication skills is code. Students are expected to be able to mention some scientific language during the interview process. During the interview process students can mention the scientific language obtained from the first question in this third indicator. The following is a transcript of students' answers to the question of mentioning some scientific language that students know.

"*I know some kak, there are temperature, heat, expansion, conductors, insulators, convection, radiation, and energy efficiency.*" (Code)

The second question in the third indicator of scientific communication skills supports the interview results in the first indicator, namely regarding the use of scientific language. The following is an example of a student answer script on the question of whether carbon gas emissions are included in scientific language and provides the reason.

"*Yes, because carbon gas emission means the release of carbon dioxide gas into the air.*" (Code)

The fourth indicator of scientific communication skills is representation form. Students are expected to be able to mention the support of scientific evidence regarding the phenomenon of carbon gas emissions. The following is a transcript of student answers to the question of what evidence support you provide regarding the phenomenon of carbon gas emissions.

"*For example, by doing an experiment we can measure the air temperature in a place where many vehicles pass by and compare it with a quiet place.*" (Representation Form)

The second question of the fourth indicator of scientific communication is representation form. Students are expected to be able to provide reasons for experiments that have been carried out during the learning process in relation to solutions to achieve the 7th SDGs. During the interview process students can explain that the experiments that have been carried out have a connection with the 7th SDGs. The following is a transcript

of student answers to the question whether the simple solar cooker and simple thermostat experiments are related to the solution to achieving the 7th SDGs.

"*Yes, both experiments can be a solution to reduce the 7th SDGs, the solar cooker can utilize free solar energy and does not produce pollution, the thermostat can regulate the room temperature so that it is not too hot or too cold, so we can save the use of electrical energy.*" (Representation Form)

Based on the interview results, students' scientific communication skills in discussing SDGs issues showed positive developments. Students are able to express their opinions and discuss related topics more confidently. However, there are still shortcomings in the use of appropriate scientific terms, which need to be improved through further practice and guidance. The scientific communication skills of junior high school students in discussing SDGs issues related to temperature, heat, and expansion showed a significant improvement supported by supporting data, namely the use of STEM-SDGs-based LKPD. The scientific communication skills of junior high school students in discussing SDGs issues related to temperature, heat, and expansion showed a significant improvement through the use of STEM-SDGs-based LKPD.

Based on the results of observations and interviews, it is found that through learning using STEM-SDGs-based LKPDs can identify the learning process of students in terms of scientific communication skills. This finding is in accordance with Munawaroh and Wahidin (2022) who stated that STEM learning can teach and improve scientific communication because students gain experience, interviews, as well as the ability to respond to a problem. With STEM learning, students are able to play an active role because they are free to argue, so students are more active in communicating. However, there is an indicator of the use of scientific language terms, the results of this study show that students are still not maximized in their use during the learning process. This condition is also in accordance with research by Paojiah et al., (2021) regarding scientific communication skills, which states that a student's ability to vary scientific sentences reaches 60% in the sufficient category. Students are more accustomed to using everyday language when discussing with their group colleagues, but even though students use scientific language terms, the frequency of use is much less than the use of everyday language. The results of this study indicate that although STEM-SDGs learning can improve students' scientific communication skills, further efforts are still needed to improve the use of appropriate scientific language terms in students' scientific communication.

## ▪ CONCLUSION

STEM-SDGs-based LKPD plays a role in improving students' scientific communication skills. This is because the STEM-SDGs-based LKPD has been prepared by 25% to support each indicator. The STEM approach that integrates various disciplines encourages students to actively participate and discuss, thus strengthening their understanding of complex scientific concepts. Based on the analysis of students' scientific communication skills after using the STEM-SDGs-based LKPD, it was found that the highest student condition was in the fourth indicator, namely representation form (86%) with a very good category. While the lowest student condition in the third indicator, namely the use of scientific terms (code), which tends to be low with a deficient category (72%). The interview results show that students understand concepts related to SDGs and

can explain scientific phenomena, but still use colloquial language rather than appropriate scientific terms.

## ▪ REFERENCES

Afkarina, D., Putra, P. D. A., and Lesmono, A. D. (2024). *Analisis keterampilan scientific communication siswa sma melalui pembelajaran stem-sdgs pada materi pemanasan global.* Jurnal Pendidikan Fisika, 12(1), 54–67. Retrieved from https://ojs.fkip.ummetro.ac.id/index.php/fisika/article/download/9557/3444

Afriana, J., Permanasari, A., & Fitriani, A. (2016). *Penerapan project based learning terintegrasi STEM untuk meningkatkan literasi sains siswa ditinjau dari gender.* Jurnal Inovasi Pendidikan IPA, 2(2), 202–212. Retrieved from https://journal.uny.ac.id/index.php/jipi/article/download/8561/9022

Afriani, D., Wilujeng, I., & Kuswanto, H. (2019). Implementation of problem based learning model assisted edmodo to measure students scientific communication skills. In Journal of Physics: Conference Series, 1233(1). Retrieved from https://iopscience.iop.org/article/10.1088/1742-6596/1233/1/012041/pdf

Aini, E. N. (2023). *Peningkatan kemampuan komunikasi ilmiah peserta didik kelas xi menggunakan pembelajaran inkuiri berbantuan simulasi phet pada materi fluida dinamis.* Journal of Learning, Teaching, and Instruction. 3(11): 1-11.

Ardhani, A. D., Ilhamdi, M. L., & Istiningsih, S. (2021). *Pengembangan media pembelajaran berbasis permainan monopoli pada pelajaran ilmu pengetahuan alam (IPA) Kelas IV SD.* Jurnal Pijar Mipa, 16(02), 170–175. Retrieved from https://jurnalfkip.unram.ac.id/index.php/JPM/article/view/2446

Ardwiyanti, D., Prasetyo, Z. K., & Wilujeng, I. (2021). STEM research trends in indonesia: A systematic literature review. Journal of Science Education Research Journal, 1.

Arifin, A. M., Pujiastuti, H., and Sudiana, R. (2020). *Pengembangan media pembelajaran STEM dengan augmented reality untuk meningkatkan kemampuan spasial matematis siswa.* Jurnal Riset Pendidikan Matematika, 7(1), 59–73. https://doi.org/10.21831/jrpm.v7i1.32135

Asri, A. A., Ghullam, H., & Deni, H. (2023). *E-LKPD berbasis education for sustainable development berorientasi literasi dan numerasi di SD.* Naturalistic: Jurnal Kajian Dan Penelitian Pendidikan Dan Pembelajaran, 8(1), 1–10. https://doi.org/10.35568/naturalistic.v8i1.2318

Dankenbring, C. A., Guzey, S. S., & Bryan, L. A. (2023). Legitimation code theory as an analytical framework for integrated STEM curriculum and its enactment. Research in Science Education. https://doi.org/10.1007/s11165-023-10103-y

Fithri, S., Pada, A. U. T., Artika, W., Nurmaliah, C., and Hasanuddin, H. (2021). *Implementasi LKPD Berbasis STEM untuk meningkatkan keterampilan berpikir kritis peserta didik.* Jurnal Pendidikan Sains Indonesia, 9(4), 555–564. https://doi.org/10.24815/jpsi.v9i4.20816

Handayani, F. (2020). *Membangun keterampilan berpikir kritis siswa melalui literasi digital berbasis STEM pada masa pandemik covid 19.* Cendekiawan, 2(2), 69–72. https://doi.org/10.35438/cendekiawan.v2i2.184

Ika, Y. E. (2018). *Pembelajaran berbasis laboratorium ipa untuk melatih keterampilan komunikasi ilmiah siswa SMP Kelas VII.* JIPFRI (Jurnal Inovasi Pendidikan Fisika Dan Riset Ilmiah), 2(2), 101–113. https://doi.org/10.30599/jipfri.v2i2.338

Ismail, S. M., and Wahidin, W. (2022). *Komunikasi ilmiah siswa sekolah dasar melalui proyek permainan stem* (sains, technology, engineering, and mathemathic). Jurnal Basicedu, 6(4), 6967–6974. https://doi.org/10.31004/basicedu.v6i4.3439

Itsnaini, S. M., Muzzazinah, M., & Ramli, M. (2018). The analysis of scientific communication pattern in high school biology class. Edusains, 10(1), 8–15. https://doi.org/10.15408/es.v10i1.6843

Kulgemeyer, C. (2018). Impact of secondary students' content knowledge on their communication skills in science. International Journal of Science and Mathematics Education, 16, 89–108. Retrieved from https://link.springer.com/article/10.1007/s10763-016-9762-6

Miles, M. B., & Huberman, A. M. (1984). Qualitative data analysis: a sourcebook of new methods. SAGE publications Inc.

Munawaroh, S., & Wahidin. (2022). *Komunikasi ilmiah siswa sekolah dasar melalui proyek permainan STEM* (sains, technology, engineering, and mathemathic). Jurnal Basicedu, 6(4), 6967–6974. doi: https://doi.org/10.31004/basicedu.v6i4.3439

Nugroho, O. F., Juwita, S. R., and Febrianti, N. (2022). STEM education planning based on contextual issues sustainable development goals (SDGs). Pedagonal: Jurnal Ilmiah Pendidikan, 6(2), 159–168. Retrieved from https://journal.unpak.ac.id/index.php/pedagonal/article/viewFile/5554/3435

Nurlaelah, I., Widodo, A., Redjeki, S., and Rahman, T. (2020). *Analisis kemampuan komunikasi ilmiah peserta didik pada kegiatan kelompok ilmiah remaja berbasis riset terintegrasi keterampilan proses sains.* Quagga: Jurnal Pendidikan Dan Biologi, 12(2), 194. https://doi.org/10.25134/quagga.v12i2.2899

Oktapiani, N., & Hamdu, G. (2020). *Desain pembelajaran stem berdasarkan kemampuan 4c di sekolah dasar.* Jurnal Ilmiah Pendidikan Dasar, 7(2), 99. https://doi.org/10.30659/pendas.7.2.99-108

Panggabean, F., Simanjuntak, M. P., Florenza, M., Sinaga, L., & Rahmadani, S. (2021). *Analisis peran media video pembelajaran dalam meningkatkan hasil belajar ipa smp.* JPPIPAI: Jurnal Pendidikan Pembelajaran Ilmu Pengetahuan Alam Indonesia, 1(2), 1-12.

Pawestri, E., & Zulfiati, H. M. (2020). *Pengembangan lembar kerja peserta didik (lkpd) untuk mengakomodasi keberagaman siswa pada pembelajaran tematik kelas II di SD Muhammadiyah Danunegaran.* Trihayu: Jurnal Pendidikan Ke-SD-An, 6(3), 903-913. Retrieved from https://core.ac.uk/download/pdf/328101650.pdf

Permatasari, I. S., Nugraha, A., and Putri., A. R. (2024). *Prototipe pengembangan E-LKPD berbasis sdgs poin ke-7 untuk memfasilitasi berpikir kritis siswa pada materi energi.* Pendas:Jurnal Ilmiah Pendidikan Dasar, 09(2), 5725–5739. Retrieved from https://journal.unpas.ac.id/index.php/pendas/article/view/14524/6751

Pramono, H., & Nana. (2019). *Upaya peningkatan kemampuan kognitif dan komunikasi ilmiah siswa kelas X MIA 1 SMA Negeri 1 Ciamis menggunakan model pembelajaran inquiry.* Diffraction, 1(1), 1–10. Retrieved from https://jurnal.unsil.ac.id/index.php/Diffraction/article/download/812/529

Putra, P. D. A., Sulaeman, N. F., Supeno, & Wahyuni, S. (2021). Exploring students' critical thinking skills using the engineering design process in a physics classroom. He Asia-Pacific Education Researcher, 1–9. Retrieved from https://link.springer.com/article/10.1007/s40299-021-00640-3

Putri, M. O. S., Putra, P. D. A., & Ridlo, Z. R. (2024). *Pengembangan modul IPA Berbasis STEM untuk meningkatkan keterampilan pemecahan masalah bagi siswa SMP*. Jurnal Pendidikan Mipa, 14(1), 289–297. Retrieved from https://doi.org/10.37630/jpm.v14i1.1490

Rianingsih, D., Mawardi, M., and Wardani, K. W. (2019). *Penerapan model pembelajaran tps (think pair share) dalam rangka meningkatkan keterampilan komunikasi siswa kelas 3.* NATURALISTIC : Jurnal Kajian Penelitian Pendidikan Dan Pembelajaran, 3(2), 339–346. https://doi.org/10.35568/naturalistic.v3i2.394

Rusminati, S. H., & Juniarso, T. (2023). *Studi literatur: STEM untuk menumbuhkan keterampilan abad 21 di sekolah dasar.* Journal on Education, 5(3), 10722– 10727. https://doi.org/10.31004/joe.v5i3.1974

Safitri, A. O., Yunianti, V. D., & Rostika, D. (2022). *Upaya peningkatan pendidikan berkualitas di indonesia: analisis pencapaian sustainable development goals* (SDGs). Jurnal Basicedu, 6(4), 7096–7106. https://doi.org/10.31004/basicedu.v6i4.3296

Sakti, I., Nirwana, N., and Defianti, A. (2022). *Implementasi pembelajaran berbasis stem pada mata kuliah kajian ipa-1 materi suhu dan kalor untuk meningkatkan literasi sains mahasiswa.* Jurnal Kumparan Fisika, 5(2), 131–140. https://doi.org/10.33369/jkf.5.2.131-140

Sari, G. M. A., Antika, V. Y., Wisutama, R. A., Syiami, L. N., Sulaeman, N. F., Nuryadin, A., & Subagiyo, L. (2022). New Indonesian science curriculum for junior high school: A content analysis to support STEM SDGs. Jurnal Literasi Pendidikan Fisika (JLPF), 3(2), 176-182. Retrieved from https://jurnal.fkip.unmul.ac.id/ index.php/JLPF/article/download/1555/953/

Sriyati, Amelia, & Soniyana. (2018). Application of expert-notice dialogue (END) method to assess students' science communication ability on biology. Journal of Physics: Conference Series, 1013(1). https://doi.org/10.1088/1742-6596/1013/1/012005

Sugiyono. (2016). *Metode penelitian kuantitatif, kualitatif, dan R&D.* Bandung: Alfabeta.

Sulaeman, N. F., Triwulandari, S., and Syam, M. (2022). Development of stem-based teaching materials with engineering design process model on global warming: validity aspect. Jurnal Pembelajaran Fisika, 11(2), 69. https://doi.org/10.19184/jpf.v11i2.31534

Taufiq, M., and Rokhman, F. (2020). Scientific communication skills profile of prospective science teachers based on sociocultural aspects. Jurnal Pendidikan IPA Indonesia, 9(2), 187–193. Retrieved from https://journal.unnes.ac.id/nju/jpii/ article/download/24366/10474