Innovations in Science Education and Practice, 1(2), 2024, 102-111

The correlation between science process skills and scientific literacy with learning outcomes of vibrations, waves, & sound

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Article History
Received: 9 October 2024
Revised: 16 November 2024
Accepted: 30 December 2024

Keywords
Correlation relationship
Learning outcomes
Science process skills
Scientific literacy

Abstract
This study aims to determine the correlation between science process skills and scientific literacy with learning outcomes of vibrations, waves, & sound. The study uses a quantitative approach with correlational research. Sampling technique using simple random sampling with data collection techniques using multiple choice questions tests. The independent variables used are science process skills and scientific literacy and the dependent variable used is student learning outcomes. The subjects of this study were students of classes VIII B and VIII C at SMP Al-Islam 1 Surakarta for the 2023/2024 academic year with a total sample of 59 students. The bivariate correlation test between science process skills and learning outcomes obtained a calculated r of 0,538 and the bivariate correlation test between scientific literacy and learning outcomes obtained a calculated r of 0,544. The multiple correlation test obtained a calculated r of 0,614 (r table = 0,256). Based on the results of the study, it can be concluded that there is a correlation between science process skills and scientific literacy with learning outcomes of vibrations, waves, & sound.

1. Introduction

Natural Sciences is a subject that contains natural events or phenomena, identifies processes and formulates problems in observing natural phenomena, and ways to discover answers and fathom issues (Yusnidar et al., 2024). Science learning in schools is anticipated to assist students play a dynamic part in learning about identity and nature so that they are able to apply it in daily life, teachers are one of the important factors that decide the accomplishment or unsuccessful of learning (Novitasari et al., 2023). Other factors that can influence learning outcomes are school culture, intrigued in learning, and student inspiration. In the event that the school culture supports the learning process, the school community will collaborate in effort to accomplish learning goals (Purnadewi et al., 2023). The application of science can function as problem identification and problem-solving methods so that it can assist students in the learning process at school or outside of school, because the nature of science is built on scientific attitudes, scientific processes, and scientific products (Sayekti, 2019).

Science learning requires an assessment to find out how much knowledge, skills, and attitudes are obtained from the science learning process that students have carried out. Student assessment of the knowledge domain includes logic, analysis, and students' thinking processes which consist of six stages, specifically recalling, understanding, applying, analyzing, assessing, and creating (Yuberti, 2015). Analysis of knowledge abilities in junior high school science learning shows that each student with different levels of achievement has different knowledge abilities measured based on six stages of the knowledge domain, in the six stages there are several aspects of knowledge that are considered still lacking or very lacking so that the science learning outcomes obtained are in the low category (Sari et al., 2020). Each student has different characteristics and the extent to which students absorb the material taught in class is also different when the learning process is given theoretically. Teachers must be able to choose and apply learning models that can encourage student participation and enjoyment in the classroom, including learning models and techniques that are in line with the subject matter. One of the causes of student learning outcomes receive low scores is the lack of direct student participation in the teaching and learning process. So a student-centered learning model is needed that facilitates the exchange of knowledge between students and teachers, students also need to train themselves to work together with classmates in solving problems and improving their understanding of a concept (Hafitri & Efwinda, 2024).

Science learning requires an ability to conduct scientific investigations, one of which is using science process skills that can train students regarding the steps or scientific methods to find a problem and then solve it. According to the statement in Permendiknas Number 22 of 2006 concerning Content Standards which emphasizes providing direct learning experiences by using and developing scientific process skills and attitudes in science learning at the junior high school/MTs level. Science process skills are a set of abilities that can be exchanged, acknowledged in numerous areas of science, and reflect the behavior of scientists. It includes observing, classifying, measuring, predicting, concluding, and communicating, defining operationally, controlling variables, formulating hypotheses, and conducting experiments (Padilla, 1990). Students should be able to integrate various abilities or skills, knowledge, and attitudes towards science to form it simpler for students to perceive science concepts better (Ederon et al., 2024). Science process skills can assist students develop essential abilities for students in carrying out scientific activities and a sense of obligation in learning (Inayah et al., 2020; Ongowo & Indoshi, 2013).

Improving from basic science process skills to integrated science process skills requires an understanding of science (Romadhona and Suyanto, 2020). Science process skills require students to utilize the information they gain to obtain ideas that can be utilized as a solution to fathom an issue, which needs to train students through the learning process carried out so they can apply it in daily life (Hacıeminoğlu et al., 2022). The choice of learning model or educational strategy can affect science process skills and student learning outcomes (Soltani, 2020). The outcomes of the study by Sari et al., (2017) concluded science process skills have a very high level of contribution to student learning outcomes. According to research by Asniar (2019), science process skills have a significant influence on student learning outcomes. The usage of the science process skills approaches significantly enhance students' science learning outcomes. There is a real change from low to high scores after the implementation of science process skills which identifies an increase in students' understanding of science material effectively (Wahyuni et al., 2024).

Scientific literacy is another ability that needs to be applied is science learning which are essential for students capable to face situations in everyday life. Scientific literacy according to the OECD (2023) is the capacity of individual to partake in issues related to science & scientific ideas. Someone who understands science is willing to participate in contemplated talk about science and technology that need competence to clarify phenomena scientifically, assess and design scientific investigations, and decipher information and prove deductively. In its development scientific literacy has four aspects, namely competence, knowledge or scientific content, scientific context, and attitude. Among these aspects, competence is the core of scientific literacy, aspects of knowledge and attitudes contribute to student competence, scientific literacy is realized in a real context that requires someone to use their competence (Zhang et al., 2023). The connection between the scientific literacy approach & scientific literacy skills can provide students with a good understanding of the material provided by providing fun learning activities and with scientific literacy students can understand the material being studied (Oktaviani & Faizah, 2024).

According to PISA data, students' scientific literacy skills in Indonesia are below average when compared to the international average score. Based on PISA data compared to the results of scientific literacy in 2018, Indonesia's score decreased by 13 points in 2022 (Siaran Pers Kemendikbud, 2023). This is one the proof that Indonesia has a lack of science literacy, one of the factors that makes science literacy in Indonesia in the low category is because science learning is more about memorization or theory with a lack of application of aspects of science literacy in the science learning process in the classroom. Things that affect students' difficulty in dealing with science literacy questions are that students rarely face questions in the form of science literacy, teachers are less than optimal in training their students to answer questions that use high-level thinking, and students' low awareness of reading and seeking knowledge outside of school (Ramli et al., 2022).

The final objective of this study is to determine the correlation between science process skills and scientific literacy with learning outcomes of vibrations, waves, and sound.

2. Method

The research approach used is a quantitative approach with a correlational research type to determine the relationship between independent variables and dependent variables. In this study, the independent variables used are science process skills and scientific literacy and the dependent variable is student learning outcomes. Established variables is measured by a multiple-choice question sheet to evaluate science process skills, scientific literacy, and learning outcomes that have been tested for validity and reliability to be tested on students. The research respondents were class VIII B and VIII C of Al-Islam 1 Junior High School Surakarta with a total of 59 students. The science process skills test consists of nine multiple-choice questions referring to aspects of science process skills: observing, classifying, measuring, predicting, concluding, communicating, and formulating hypotheses (Padilla, 1990). The scientific literacy test consists of seven multiple-choice questions referring to aspects: science knowledge, competence, science context, and attitude (OECD, 2017). The learning outcome test contains six multiple choice questions based on the aspects: remembering, understanding, applying, analyzing, and creating (Anderson and Krathwohl, 2001). The science material used as test is from the odd semester material of the 2023/2024 academic year. The materials used for learning outcomes are vibrations, waves, and sound. The materials used for science process skills and scientific literacy are basic sciences.

The instrument validation technique was tested by looking at the r value from the Pearson Product Moment test and the reliability of the question instrument was tested by looking at the Cronbach Alpha value. Hypothesis testing is carried out using a bivariate correlation test with Pearson Product Moment and multiple correlation test with the help of SPSS 21 application with a significance level of 5%. The criteria of correlation analysis is, if the Sig. value < 0,05 (r count > r table) then it shows a significant correlation between the independent variables and the dependent variable. Table 1 below is interval value of students score achievement.

Table 1. Interval Value of Student Score Achievement

Interval Value	Category
85-100	Very High
71-84	High
65-70	Moderate
55-64	Low
0-54	Very Low

3. Results and Discussion

This study was conducted in classes VIII B and VIII C of Al-Islam 1 Junior High School Surakarta of the 2023/2024 academic year with a total of 59 students. Data on students' science process skills, scientific literacy, and learning outcomes were obtained from multiple choice questions instruments based on each aspect of established variables. In working on multiple choice questions, students are asked to chooses one correct answer from the four answers provided on the answer sheet. Science process skills relate to scientific methods for finding and solving problems. Scientific literacy according to the OECD (2023) is the capabilities of an individual to partake in issues regarding to science and scientific thoughts. In Figure 1 below is the average score of science process skills referring to aspects: observing, classifying, measuring, predicting, concluding, communicating, and formulating hypotheses from 59 students of Al-Islam 1 Junior High School Surakarta.

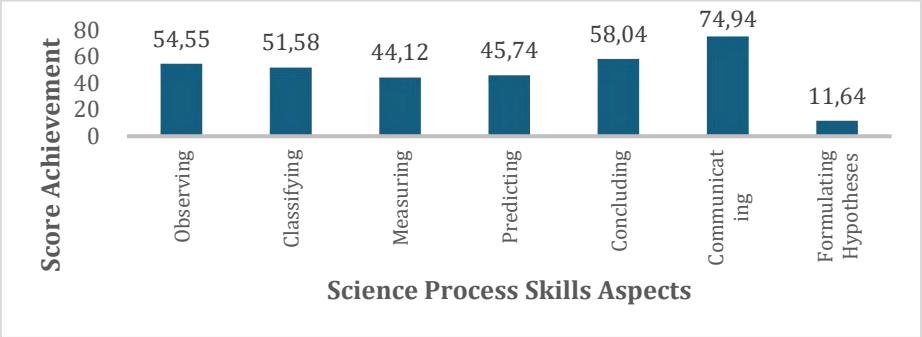

Figure 1. Average Scores of Science Process Skills

Based on Figure 1 the highest average score of the science process skills is in the communicating aspect with an average score of 74,94 in the high value category and the lowest average is in the hypothesizing aspect with an average score of 11,64 in the very low category. Which means that students are able to convey opinions from a description but are still lacking in compiling statements to explain an event that can be tested. Overall, students' science process skills are low because of the seven aspects tested, six of them are still in the low and very low categories. Integrated science process skills have a lower score compared to basic process skills, because before students can master integrated science process skills, students must first master basic science process skills.

The following are the average score of scientific literacy of students in grades VIII B and VIII C of Al-Islam 1 Junior High School Surakarta. Based on Figure 2, the highest average score of scientific literacy is in the science knowledge aspect with an average score of 83,01 in the high category, while the lowest average is in the science context aspect, with an average score of 45,07 in the very low category. This means that students can master concepts in science but are still lacking in the application of science in everyday life. Overall, from the aspects of science literacy used in this study, only the science knowledge aspect has an average score in the high category, which can be said that students have mastered this scientific literacy aspect. However, in the aspects of science literacy, namely competence, science context, and attitude, the average score is still in the low and very low categories, which shows that students have not been able to master the aspects of competence, science context, and attitude.

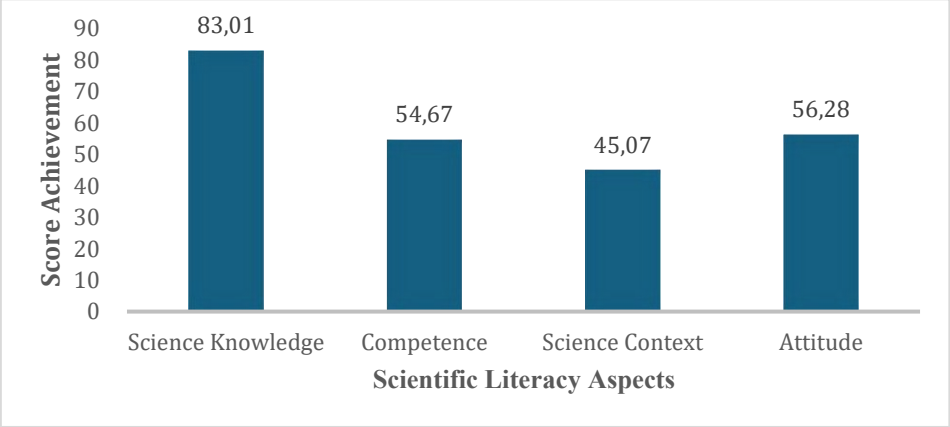

Figure 2. Average Scores of Scientific Literacy

Learning outcomes are the achievements obtained by students in the form of knowledge, skills, and attitudes of students through the learning process carried out at school which are converted into numbers. The assessment of learning outcomes in this study is in the knowledge domain to determine how much students have mastered the science learning materials that have been taught in class. The following are the results of the learning outcome test of class VIII B and VIII C students of Al-Islam 1 Junior High School Surakarta.

Based on Figure 3 the highest average result of the learning outcome test is in the remembering aspect with an average value of 60,71 in the low category and the lowest average is in the analyzing aspect, namely with an average value of 49,54 in the very low category. Which means that students are able to store knowledge in the long term but have not been able to sort a material into parts and then connect them in a structured way. Overall, student learning outcomes are still low because of the five aspects tested, all are in the low and very low categories.

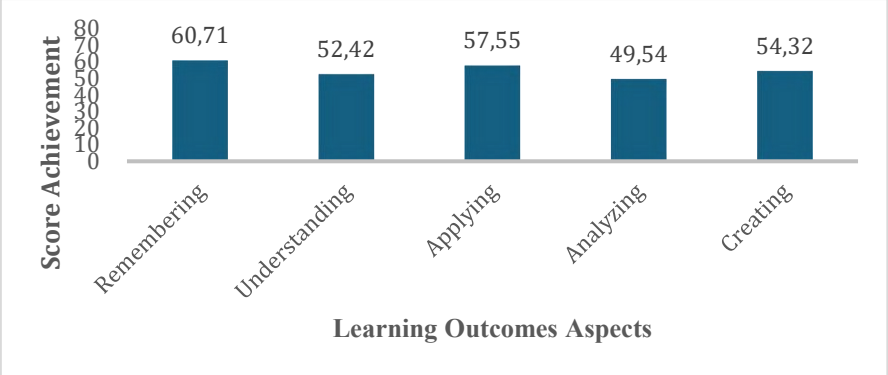

Figure 3. Average Scores of Learning Outcomes

Based on Table 2, there are two questions based on remembering aspects. One of them are students need to give a definition of vibration that gets an average value of 66,70 in the moderate category. the questions are made as simple as: Vibration is, but based on the result there are students who can't understand the correct answers to the multiple choices provided. Another question are students need to distinguish between transverse waves and longitudinal waves that gets an average value of 54,72 in the very low category. Students failed to select the basic differences between transverse waves and longitudinal waves, the answers provided are frequency, amplitude, direction of propagation, and wavelength. Based on the definition of transverse waves, the direction of propagation is perpendicular to the direction of vibration, while the direction of longitudinal waves is parallel to the direction of vibration. The average score of two questions based on remembering aspects are 60,71 in the low category.

Table 2. Learning Outcomes Test Indicators

No	Question Indicators	Learning Outcomes Aspects
1	Students are able to explain the definition of vibration	Remembering
2	Students are able to interpret the graphs of the relationship between string length and squared period in the harmonious vibration's pendulum	Analyzing
3	Students are able to distinguish between transverse waves and longitudinal waves	Remembering
4	Students are able to differentiate echoes and reverberations	Understanding
5	Students are able to calculate the sound source distance to the listener	Applying
6	Students are able to formulating hypothesis of electromagnetic waves spectrum	Creating

Questions on the understanding aspects, students are asked to indicated the difference between echo and reverberation with the answers provided are distance from the sound source to the listener, completeness of words heard, distance from the sound source to the reflective wall, and amplitude & frequency. But the results obtained were very low average scores (52,42). Based on the result students still have difficulty understanding something after knowing and remembering stage. Questions on the applying aspects, students are asked to calculate the distance of sound source to the listener. In the question, the time and velocity of sound are known. To calculate distance (s), obtained by multiplying velocity of sound (v) and time (t) with the formula $s = vt$. But the results obtained were low average scores (57,55). Based on the result students still haven't been able to use theories, principles, ideas, or procedures in real situations to solve problems. Questions on the analyzing aspects, students are asked to interpret the graphs ($l\text{-}T^2$) of pendulum vibrations. The answers provide images of various graphs ($l\text{-}T^2$) and students are asked to choose the correct graphic image regarding the $l\text{-}T^2$ relationship on the harmonious pendulum vibrations. But the results obtained were very low average scores (49,54) with the lowest average scores compared to others aspects. Questions on the creating aspects, students are asked to formulating hypothesis by giving a picture of electromagnetic waves spectrum with its wavelength, students are needed to arrange the electromagnetic waves from largest to smallest. But the results obtained were very low average scores (54,32). Students still have difficulty sorting electromagnetic waves based on pictures even though there are wave names and wavelengths in the pictures given among the four answers provided in the multiple-choices.

Students are passive in asking or answering questions during the learning process and students' learning outcomes are below minimum completeness criteria (Atmoko et al., 2024). Because most of

educating styles centered on lectures and students receiving knowledge just from teachers, morever teachers have not given cases to prompted students to associate knowledge and apply in everyday life (Kwangmuang et al., 2021). If the understanding of students' concepts of vibrations, waves, and sound is accomplished, students will have no trouble applying science, so learning outcomes can enhance (Saida et al., 2023). Students who aware of the benefits of learning and able to know the learning objectives can increase their learning outcomes (Harefa et al., 2023).

Normality tests and linearity tests were carried out with the help of SPSS 21. The normality test used Kolmogorov-Smirnov (α =0,05) obtained Sig. 0,685 which shows the data is normally distributed. The linearity test uses *test for linearity* (α =0,05) on science process skills with learning outcomes obtained Sig. 0,077 and scientific literacy with learning outcomes obtained Sig. 0,984 which can be concluded that between the two variables is linear because Sig. > 0,05. The following is a summary of the hypothesis test in tabular form.

From 59 samples of junior high school students in grade VIII for the correlation between science process skills with learning outcomes, the significance value is less than α or Sig. < 0,05, namely 0,00 < 0,05 with r count > r table (0,538> 0,256) (Table 3), resulting in the conclusion that H_0 rejected or there is a relationship between science process skills and learning outcomes in science subjects in the category of a moderate correlation level. This result is related to the research of Putri et al. (2019) which states that there is a correlation between basic science process skills and learning outcomes which shows a positive and significant relationship but in the category of moderate correlation level (r count = 0,43), in the completion of cognitive learning outcomes, many students obtained scores below the passing grade, one of the factors that causes students' scores below the passing grade is low learning motivation and difficulty concentrating in implementing learning, so that what has been taught to students is not stored in memory or students do not understand a material but do not ask or seek other information independently. Research shows that students have not been able to obtain information from the five senses, group objects, describe dimensions with measuring instruments, predict possibilities, provide structured explanations, and make temporary assumptions.

Table 3. Correlation Test Results

Variable	Sig.	r Count	r Table	Conclusion
Science Process Skills with Learning Outcomes	0,000	0,538	0,256	H_0 rejected
Scientific Literacy with Learning Outcomes	0,000	0,544	0,256	H_0 rejected
Science Process Skills and Scientific Literacy with Learning Outcomes	0,000	0,614	0,256	H_0 rejected

Basic science process skills determine the level of learning outcomes obtained. The results of a meta-analysis study of 18 research samples selected from 2005-2020 regarding the relationship between science process skills and science learning outcomes, there is a moderate and positive relationship between science process skills and learning outcomes. Based on these findings, it was found that the higher the use of science process skills, the higher the learning outcomes will be (Dolapcioglu & Subası, 2022). The reason science process skills are very useful in the learning process is because the development and advancement of technology and the rapid growth of knowledge require students able to find and process informations from different sources (Aditiyas & Kuswanto, 2024). Students can improve their science process skills by continuing to search for the latest information and processing it so that they can keep up with the development of knowledge. Students who have high science process skills will discover it simpler to illuminate issues in learning so their learning outcomes will also be high (Yusnidar et al., 2024). Science process skills are important for students as a tool to explore and investigate nature, improve learning outcomes and attitudes towards science, learn science with better understanding, and develop thought processes (Gizaw & Sota, 2023). Combining scientific concepts with real contexts and involving students in hands-on activities related to nature, students can use integrated science process skills to gain a deeper understanding of the subjects (Melesse et al., 2025).

The correlation between the scientific literacy variable and learning outcomes has a significance value of less than α or Sig. < 0,05 (0,00 < 0,05) and r count > r table (0,544 > 0,256), resulting in the conclusion that H_0 rejected or there is a correlation between scientific literacy and learning outcomes in science subjects in the category of a moderate correlation level. Based on research by Nufus et al. (2021) which concluded that scientific literacy has a significant relationship with learning outcomes.

Based on this study, the type of learning (visual, auditory, kinesthetic, and reading/writing) does not have a different effect on learning outcomes and scientific literacy, but it was found that scientific literacy has a significant effect on learning outcomes. The results of research by Jufrida et al. (2019), from a total of 138 students from three junior high schools in Muaro Jambi, it was concluded that between scientific literacy and science learning outcomes there was a relationship at a low correlation coefficient (r count = 0,292) with an average scientific literacy score in the moderate category and an average learning outcome score in the very low category. Based on research by Mashudi et al. (2024) concluded that using guided discovery-based modules can help students improve their scientific literacy and independent learning skills, the positive influence is due to reinforcing factors such as increasing student learning activities, students' thinking skills will develop and vary in using learning resources. Student activities have increased in participating and in learning, increasing reciprocal ties between teachers & students and between students as well as student participation in making conclusions after learning. Low scientific literacy can be influenced by students' low interest in reading, evaluation tools that do not yet lead to scientific literacy, and teachers' lack of knowledge about scientific literacy (Sutrisna, 2021).

Factors that cause low level on scientific literacy are based on students, teachers, and schools. In students, students are not yet able to understand the basic concepts of science taught by teachers but do not ask questions, and students are less interested in reading and repeating learning materials. In teachers, scientific literacy is not trained enough in students which causes students to be unaccustomed to dealing with problems regarding scientific literacy. In schools, science learning is still carried out conventionally, there is a lack of urgency regarding the essential of scientific literacy/reading & writing skills as competencies students must be owned, and school facilities that don't favor the learning process to hone scientific literacy skills (Yusmar & Fadilah, 2023). Increasing scientific literacy in students can occur when students themselves have the motivation to read information about life phenomena and then process it and are supported by classroom learning that has applied scientific literacy to the learning process. Students actively seek information and ask teachers or others when they find things that they do not understand. Science literacy skills can be improved with refraction, appropriate learning strategies and methods and students are needed to be educated, able to think critically and creatively, able to make decisions to solve problems, and able to communicate systematically (Saraswati et al., 2021). Scientific literacy can be improved by using guitar media to study vibrations, waves, & sounds and learning to make a simple guitar can train students' science literacy (Ramli et al., 2024). For online scientific literacy learning can use safe exam browser applications which limits students from browsing on the computer so that students' movements are limited to question given (Gina et al., 2024). Scientific literacy requires a multidisplinary and comprehensive approach to foster development of critical thingking, effective communication, and an understanding of science (Nwagwu, 2024). Hands-on nature based learning can expand environmental mindfulness and scientific literacy (Restović & Bulic, 2024). The existence of the appropriate learning method in the learning process can help students to have critical thinking and creativity in dealing with problems. Learning model with scientific literacy brings the students to engage with problem-solving process (Sutiani et al., 2021).

The results of the multiple correlation test have a significance value of less than α or Sig. < 0,05 (0,000 < 0,05) and r count > r table (0.614 > 0,256), resulting in the conclusion that H_0 rejected or concluded that there is a correlation between science process skills & science literacy with learning outcomes of junior high school students in science subjects in strong correlation category. As discussed previously in the bivariate correlation hypothesis test of the correlation between science process skills and science learning outcomes and the correlation between scientific literacy & science learning outcomes. Both show a correlation at a fairly strong or moderate level of correlation. Science process skills are affected by learning habits, facilities, & the science learning process in the classroom (Dewi & Muhiri, 2020). Meanwhile, the factors that affect science literacy are the low contribution of science learning because science learning is separate from the context in life, science learning emphasizes mastery of material/theory, at school students are only required to master knowledge, and low reading activities (Sari and Nurwahyunani, 2016). Overall, students are expected to increase their interest in reading and understanding information about phenomena or issues in life supported by adequate school facilities with the science learning process in the classroom.

Students' intrigued in learning and the endeavors made by teachers to create interest in learning, it was found that the quality of students intrigued in learning at school was still inadequate

because science learning was considered difficult for students (Yusnidar et al., 2024). One of the factors that influences science learning outcomes is learning media, because it can focus students in the learning process with a real picture of the information provided by the teacher to students (Astiti et al., 2021). Other factors that affect students' learning outcomes: 1) psychological factors, namely: interest and motivation to learn, talent, concentration, and learning habits, 2) school factors, namely: methods, models, and learning facilities and infrastructure, and 3) family factors, namely: parental education, parental orientation to students, and family harmony (Paramita et al., 2021). From the indicators of science learning habits in psychological factors, students still often memorize material and do not seek additional information from other sources, and from the indicators of parental background in family factors, children are less guided when studying at home (Jufrida et al., 2019). Learning does not have to be done at school but outside of school, especially at home, so parents need to give attention and guidance to children when studying at home. Children will be more motivated to learn when parents give full support to their children's efforts to learn specifically about natural science.

The researcher only conducted a small study so that there was no wider comparison of all existing classes or other methods. Another limitation is that the question sheets were tested when entering the even semester learning with the material that the researcher tested was odd semester material so that it is possible that students have forgotten most of the material that has been taught in the odd semester.

4. Conclusion

There is a correlation between science process skills and student learning outcomes in science subjects with r count > r table, namely 0,538 > 0,256 with Sig. 0,00 < 0,05, included in the category of moderate level correlation. There is a correlation between scientific literacy and student learning outcomes in science subjects with r calculated > r table, namely 0,544 > 0,256 with Sig. 0,00 < 0,05 is included in the category of moderate level correlation. There is a correlation between science process skills and literacy with student learning outcomes in the subject. Science lessons with r count > r table, namely 0.614 > 0,256 with Sig. 0,00 < 0,05 are included in the category of strong level correlation.

Author Contributions

All authors have equal contributions to the paper. All the authors have read and approved the final manuscript.

Funding

No funding support was received.

Declaration of Conflicting Interests

All authors must disclose any financial and personal relationships with other people or

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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