Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram
https://e-journal.undikma.ac.id/index.php/prismasains/index
e-mail: prismasains.pkpsm@gmail.com

April 2025. Vol. 13, No. 2
p-ISSN: 2338-4530
e-ISSN: 2540-7899
pp. 186-203

Analysis of Science Problem Solving Ability in terms of Learning Style of Junior High School Students

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Received: August 2024; Revised: January 2025; Published: April 2025

Abstract

This study aims to identify students' learning styles, assess their science problem-solving abilities, and analyze these abilities in relation to their learning styles on the topics of vibration, wave, and sound. Employing a quantitative descriptive approach, data were collected through tests, observations, and interviews. Instruments included a learning style questionnaire, problem-solving ability test, and interview guidelines. The findings reveal four learning styles among students—visual (25%), auditory (13%), kinesthetic (58%), and visual-kinesthetic (4%)—with kinesthetic being the most prevalent. However, 71% of students demonstrated low science problem-solving ability, with an average score of 52.9. Specifically, problem-solving performance was categorized as low across all four indicators: understanding the problem (36.5%), planning the solution (29.2%), implementing the solution (29.7%), and rechecking the answer (18.3%). Students with visual learning styles performed better in all problem-solving stages compared to their auditory and kinesthetic peers. This study highlights the need for tailored teaching strategies to improve problem-solving skills, particularly for students with auditory and kinesthetic learning styles, as no prior research has focused on the interplay between learning styles and problem-solving abilities in the context of vibration, wave, and sound materials.

Keywords: Learning Style; Science; Problem Solving Ability;Junior High School

How to Cite: Putri, A., Syahrin, R., Inayah, N., & Prahani, B. (2025). Analysis of Science Problem Solving Ability in terms of Learning Style of Junior High School Students. *Prisma Sains : Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram*, *13*(2), 186-203. doi:https://doi.org/10.33394/j-ps.v13i2.12581

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INTRODUCTION

Since the turn of the century, educational policies, discourses, and curricula have increasingly emphasized the importance of 21st-century skills. This shift has been driven by rapid globalization and technological advancements, which challenge the adequacy of school systems to equip students with the skills needed to succeed in the workforce (Bayley, 2022). Among these skills, critical thinking, problem-solving, creativity, innovation, communication, and collaboration are crucial (Monika et al., 2022; Redhana, 2019; Trisnawati & Sari, 2019). These competencies are expected to produce quality human resources, capable of facing 21st-century challenges and excelling in their careers (Jayadi et al., 2020; Karaca-Atik et al., 2023).

Science education, a field that investigates natural phenomena, inherently cultivates problem-solving abilities. It is comprised of three key dimensions: (1) science as a process, which involves systematic steps to address problems, (2) science as a product, consisting of facts, principles, laws, and theories, and (3) science as a scientific attitude, which includes values and morals (Narut & Supradi, 2019). Among the various science topics taught in junior high school, the concepts of vibrations, waves, and sound—covered in KD 3.11, Semester 2—serve as foundational elements for understanding natural phenomena. These topics are crucial in developing problem-solving skills, a vital aspect of 21st-century education (Rahayu et al., 2021).

Problem-solving itself is defined as a higher-order thinking process that involves identifying and implementing solutions to complex issues (Zamil et al., 2021). Students need to apply critical, creative, and effective strategies to overcome challenges and meet expectations (Murtiyasa & Wulandari, 2022). This process not only enhances individual cognitive skills but also improves communication through collaborative efforts and fosters social values (Qotrunnada & Prahani, 2022).

Polya's problem-solving stages, outlined by Anugraheni (2019), provide a structured framework to understand and assess this skill. These stages include: (1) understanding the problem, where students identify the known elements and the problem's requirements, (2) devising a plan, which involves formulating systematic steps, (3) carrying out the plan, where students implement their proposed solutions, and (4) looking back, where they reflect on their answers and explore alternative solutions.

Despite the recognized importance of problem-solving skills, assessments such as TIMSS (Third International Mathematics and Science Study) and PISA (Program for International Student Assessment) have revealed that Indonesian students' problem-solving abilities remain low. Although the Indonesian Ministry of Education and Culture has made efforts to improve the education system, international rankings in mathematics and science have shown consistent declines over time. For example, in the last five TIMSS periods, Indonesian students ranked 34th in 1999, 35th in 2003, 36th in 2007, 36th in 2011, and 44th in 2015 (Alfiani & Firmansyah, 2022; Khodaria et al., 2019). Furthermore, the 2018 PISA results indicated that 70% of Indonesian students could not reach level 2 in problem-solving, while globally, only 23% of students were in the same category (Sabora et al., 2022).

Several factors contribute to these challenges, including differences in learning styles, conceptual understanding, and individual learning habits (Pratiwi et al., 2021; Soenarjadi, 2020). Learning styles—defined as individuals' preferred methods for acquiring, processing, and presenting knowledge—significantly affect students' ability to understand and solve problems (Kulsum & Kristayulita, 2019). The primary learning styles are visual, auditory, and kinesthetic (Labu, 2021; Setiyadi, 2020). Visual learners excel in interpreting graphs, diagrams, and charts, auditory learners prefer oral instructions and discussions, while kinesthetic learners rely on movement and hands-on activities to grasp concepts (Olubela & Adebanjo, 2019).

Previous research on problem-solving abilities in relation to learning styles has focused primarily on mathematical problem-solving (Kulsum & Kristayulita, 2019). For example, Setiyadi (2020) found that visual learner outperformed those with auditory and kinesthetic styles in problem-solving tasks. Similarly, research by Rahayu et al. (2021) highlighted low problem-solving ability in the "looking back" stage, specifically for science-related problems. Despite these studies, there remains a gap in research regarding science problem-solving abilities in relation to learning styles, particularly in topics such as vibrations, waves, and sound.

Thus, the need for further investigation into science problem-solving abilities, with a focus on learning styles, is clear. By exploring how learning styles influence students' approaches to solving problems in topics like vibrations, waves, and sound, this research seeks to bridge the gap between theory and practice. Furthermore, this study aims to provide a deeper understanding of how learning styles impact students' development of essential 21st-century skills, particularly problem-solving, which is crucial for adapting to future challenges.

This study seeks to fill that gap by investigating the association between learning styles and science problem-solving ability in junior high school pupils. Unlike prior research, which largely explored problem-solving in mathematics or general science, this study focused on vibrations, waves, and sound. Furthermore, it tries to give a detailed examination of how learning styles influence the development of these abilities, so providing educators with vital insights for designing more effective teaching procedures.

METHODS

This research uses a descriptive quantitative approach with the research techniques used are interviews, observations, and tests. In addition, this research instrument uses a student learning style questionnaire adapted from O'Brien (1985), a written test of science problem solving ability, and an interview guideline sheet. The data analysis technique in this study used a percentage quantitative descriptive analysis technique on questionnaire data, the data obtained in the form of numbers which were then processed with the aim of knowing the percentage of students' learning styles, then the data obtained from the questionnaire sheet was analyzed in percentage form using the percentage descriptive analysis formula. The following is the percentage formula, namely: percentage % = n / N X 100% (Wijayanti, 2021).

The interview data were analyzed using descriptive analysis, including data reduction, data presentation, and conclusion drawing. In addition, the written test questions assessing science problem-solving ability were validated for construct validity by experts. The construct validity was calculated using Aiken's V formula (Irmawati, Syahmani, and Yulinda, 2021; Atika et al., 2022). The result is considered valid when the V value reaches a high validity threshold of 0.80 or higher (≥0.80) (Zakaria et al., 2020). Aiken’s V formula is used to measure the extent to which the evaluators agree on the relevance of the test items. It is calculated as follows.

$$\boldsymbol{V}= \frac{\sum \boldsymbol{s}}{[\boldsymbol{n}\ (\boldsymbol{c}-\boldsymbol{1})]}$$

Description:
s = r-l0
r = value of the validator
l0 = smallest value
c = greatest value
n = number of raters

Aiken's V provides a numerical indicator of the validity of the test, where a value closer to 1 indicates high agreement and thus high construct validity. Additionally, the reliability of the written test questions on science problem-solving ability was assessed using Borich’s formula (Ratnasari et al., 2022). The test is considered reliable if the agreement percentage among the raters is 75% or more (≥ 75%). The formula used to calculate the agreement percentage is as follows.

$$\textit{Percentage of Aggrement} = 1 - \left(\frac{A-B}{A+B}\right) \times 100\%$$

Description:
A = the largest value from the validator
B = the smallest value from the validator

The reliability and validity tests were highly praised for their thoroughness. The systematic construct validation process ensures that the test items are of high quality and accurately measure the intended scientific problem-solving abilities. Aiken’s V formula, in particular, is valuable in quantifying the consensus among raters about the appropriateness of the test items, with a higher V value signifying stronger validation of the test's construct. The test scores are then categorized to determine the students' levels of science problem-solving ability, as outlined in Table 1 (Hermawati et al., 2021).

Table 1. Category Level of Science Problem Solving Ability

Score Interval	Category
$75 \leq N \leq 100$	High
$60 \leq N \leq 74$	Medium
$0 \leq N \leq 59$	Low

The research population consisted of eighth-grade students from SMPN 3 Surabaya. The sampling was conducted based on the students' learning styles, with a total of 24 students selected from Class VIII A, including three representatives for each learning style. Although the sample size of 24 students may appear small, it was determined based on practical constraints such as limited time, resources, and the feasibility of conducting in-depth data collection and analysis. The sample was chosen to ensure the inclusion of diverse learning styles, providing sufficient representation for the study's objectives despite the limited size.

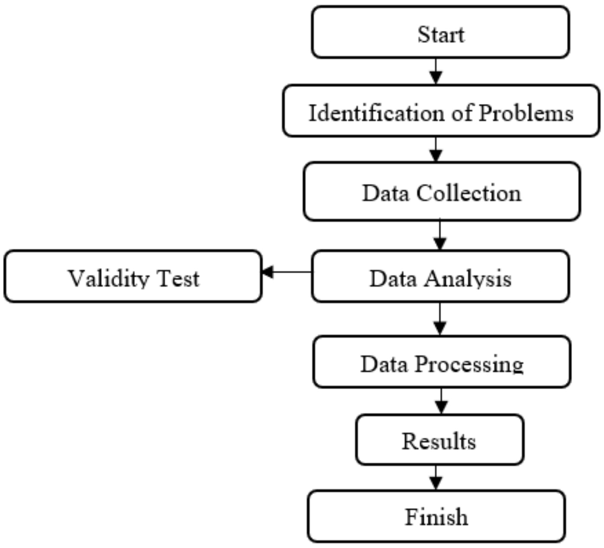


Figure 1. Flowchart of Research Method

RESULTS AND DISCUSSION

Students' learning styles are known from giving a questionnaire adapted from O'Brien (1985) which consists of 30 questions which according to the researcher are the findings of this study in categorizing learning styles. The data collection by distributing learning style questionnaires to students obtained the following results.

Table 2. Categorization of Learning Styles of Students in Class VIII A SMPN 3 Surabaya

Learning Styles	Frequency	Percentage
Visual	6	25%
Auditory	3	13%
Kinesthetic	14	58%
Visual-Kinesthetic	1	4%
Total	24	100%

Table 2 shows the learning styles of students in class VIII A SMPN 3 Surabaya, with a total of 24 students. Among them, 6 students (25%) were identified visual learner, 3 students (13%) with an auditory learning style, and 14 students (58%) with a kinesthetic learning style. The dominance of kinesthetic learners (58%, Table 2) in this sample could be attributed to various factors, such as the nature of the activities or teaching methods that may favor hands-on or movement-based learning. This finding could influence the generalization of results, as the sample may not be representative of all students, especially if kinesthetic learners have unique learning behaviors that differ from those of other learning styles. It is important to consider that this sample might not reflect the broader student population, which could impact the applicability of the findings to other settings or groups. The underrepresentation of the "visual-kinesthetic" group (only 1 student) could be due to the specific characteristics of this group, which may not align with the majority of learning styles observed in this class. This small number makes it difficult to draw robust conclusions about the specific needs or behaviors of visual-kinesthetic learners. The limited sample size in this category could potentially affect the analysis, as it may not provide enough data to understand the learning dynamics of this group thoroughly. The results of construct validity conducted by validators are shown in Table 3 and the reliability results are shown in Table 4.

Table 3. Results of Construct Validity

Aspect	Validity Score of Test Questions	Valid Criteria
Content Assessment	0,87	High
Construct Assessment	0,91	High
Language Assessment	0,86	High

Table 4. Reliability Results

Aspect	Validity Score of Test Questions	Kriteria Reliabel
Content Assessment	96,5 %	Highly Reliable
Construct Assessment	100 %	Highly Reliable
Language Assessment	100 %	Highly Reliable

Construct validity testing contains questions about whether the questions are in accordance with the scientific concepts of physics, while reliability testing contains whether the validator's assessment is consistent or reliable. The questions were reviewed by lecturers who are experts in the field of physics. The results of construct validity and reliability show that the instrument of science problem solving ability test questions that have been made by researchers have high validity criteria and are very reliable. The overall research data from the administration of the science problem solving ability test instrument is shown in the Table 5.

Table 5. Categorization of Science Problem Solving Ability of Class VIII A SMPN 3 Surabaya

Science Problem Solving Ability Category	Frequency	Mean	Percentage
High	2	69,5	8%
Medium	5	61,8	21%
Low	17	27,5	71%
Total	24	52,9	100%

Table 5 shows the low performance across all stages of problem solving. However, the discussion does not delve into the underlying causes of these results beyond general references to previous research. A deeper analysis is necessary to understand the factors contributing to this low performance in the context of students' learning styles. The data reveals that the majority of students (71%) scored low in science problem-solving ability, with only a small portion of students (8%) performing at a high level. This disparity suggests that several factors, including students' learning styles, may significantly influence their ability to solve problems effectively. Learning styles, as highlighted in previous research (Pratiwi et al., 2021; Soenarjadi, 2020), play a crucial role in determining how individuals approach problem-solving tasks. These styles dictate how students process and understand information, which in turn affects their problem-solving strategies.

For example, visual learners excel at interpreting graphs, diagrams, and charts, which may enhance their problem-solving ability in subjects that require visual representation (Afolabi, 2021). In contrast, kinesthetic learners rely more on hands-on activities and physical engagement to grasp concepts (Olubela & Adebanjo, 2019). This difference in how students approach learning and problem solving could explain why some students struggle with science problems, particularly those involving abstract concepts like vibrations, waves, and sound. Moreover, auditory learners, who tend to prefer oral instructions and discussions (Astuti et al., 2023), might face challenges in subjects where visual or kinesthetic methods are more beneficial.

Interestingly, the results from prior studies on science problem-solving skills and learning styles, such as those by Setiyadi (2020) and Kulsum & Kristayulita (2019), suggest that students visual learner tend to perform better in problem-solving tasks compared to their auditory and kinesthetic counterparts. This is supported by the finding that visual learners often excel in tasks that require interpreting and applying visual information. However, the current study shows a predominant low performance across the board, which may be indicative of the unique challenges in the science domain, particularly in complex topics such as vibrations, waves, and sound.

The gap between expectations and reality is evident when we consider the global demand for students to possess high-level problem-solving skills in the 21st century. While students are expected to be equipped to face future challenges, the data presented in Table 5 suggests that their science problem-solving abilities remain inadequate. This highlights the need for more research into how different learning styles influence students' problem-solving abilities, particularly in science, and how teaching strategies can be tailored to bridge this gap. Therefore, understanding the connection between learning styles and problem-solving performance is essential to help educators develop more effective teaching methods that accommodate diverse learning needs. Furthermore, the results of the calculation of student test responses to the four indicators of science problem solving ability are as follows (Table 6).

Table 6. Categorization Based on Indicators of Science Problem Solving Ability Class VIII A SMPN 3 Surabaya

Problem Solving Indicator	Percentage	Category
Understanding the problem	36,5%	Low
Planning to solve the problem	29,2%	Low
Implementing the plan	29,7%	Low
Rechecking the answer	18,3%	Low

Based on Table 6, it shows the results of the science problem solving ability test seen from the problem solving ability indicators. The indicator of understanding the problem obtained an average value with a percentage of 36.5%, the indicator of planning problem solving obtained an average value with a percentage of 29.2%, the indicator of implementing the problem solving plan obtained an average value with a percentage of 29.7%, and the indicator of checking the answer again obtained an average value with a percentage of 18.3%, from these data the four indicators of problem solving are categorized as low. Furthermore, the results of research on science problem solving ability with 3 items of vibration, wave, and sound material in terms of learning styles of students are explained below: In the science problem solving ability of the visual learning style precisely at the stage of understanding the problem, question number 1 can be seen in Figure 2.

Soal :

1. Ahmad memiliki sebuah jam antik yang memanfaatkan periode gerak ayunan bandul untuk gerakan mesin jamnya. Saat diperhatikan lebih lanjut, ternyata jam antik yang dimiliki Ahmad selalu lebih lambat dari seharusnya. Jika ia ingin menyelidiki pengaruh panjang tangkai bandul pada periode getaran bandul jam antiknya dan tersedia satu buah statif, tiga buah bandul, serta tiga buah tali dengan panjang masing-masing sebagai berikut: 30 cm, 40 cm, dan 50 cm.
   a) Tuliskan hal yang diketahui dari permasalahan yang diajukan!
   b) Sebutkan dan jelaskan persamaan apa yang harus digunakan untuk mencari periode getaran? Jelaskan tiap simbol pada persamaan tersebut!
   c) Jika diperoleh data percobaan sebagai berikut:

No	Panjang Tali (cm)	Jumlah Getaran	Waktu (s)
1	30	10	13
2	40	10	21
3	50	10	32

   Berapakah periode dari masig-masing percobaan tersebut?
   d) Apa kesimpulan yang kamu dapatkan dari permasalahan tersebut? Apa yang harus dilakukanAhmad agar gerakan bandul jam antiknya lebih cepat?

Figure 2. Problem Solving Test Questions on Vibration, Wave, and Sound Number 1

The results of V-1 work related to problem solving ability at the stage of understanding problem number 1 about the pendulum swing motion experiment can be seen in Figure 3.

(1.) a Ahmad mempunyai 1 buah statif, 3 buah bandul, serta 3 buah tali dengan panjang masing-masing berikut: 30 cm, 40 cm, dan 50 cm yg nantinya akan digunakan Ahmad utk memperbaiki jam antiknya. (3)

b. waktu = jumlah getaran → $\frac{s}{n}$ (2)

c. (1) $\frac{t}{n} = \frac{13}{10} = 1\frac{3}{10}$

(2) $\frac{t}{n} = \frac{21}{10} = 2\frac{1}{10}$ (3)

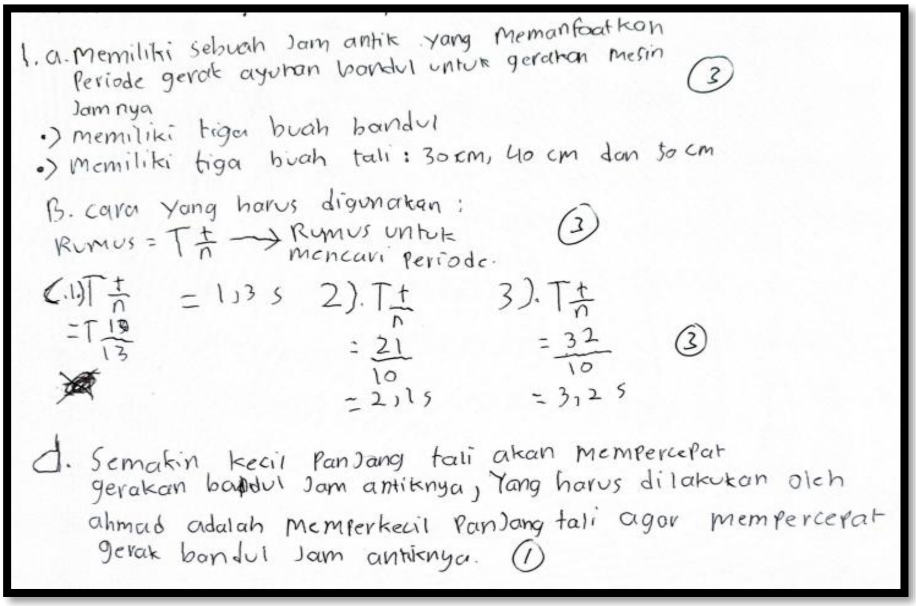
(3) $\frac{t}{n} = \frac{32}{10} = 3\frac{2}{10}$

d. Ahmad harus menggunakan percobaan ke 1 agar jam bandul antiknya bergerak lebih cepat yaitu 30 cm (3)

Figure 3. The Work Result of Subject V-1 on Problem Number 1

The combination of the test results of the problem solving ability of subject V-1 and the interview excerpts of subjects V-1 and V-2 in the stage of understanding the problem at number 1a is known to be a stative, 3 pendulums, with 3 ropes of different lengths, namely: 30 cm, 40 cm, and 50 cm. These results show that subjects with visual learning styles are able to understand the problems given. Furthermore, the planning stage of problem solving from the visual learning style, V-1's work on number 1 can be seen in Figure 3 part 1b, it can be seen that the subject can mention the plan to be used in solving the problem, namely the formula period = t / n but cannot explain the symbol of the formula used. Therefore, in problem number 1 the visual learner is able to plan problem solving quite well. Then the stage of implementing the plan from the visual learner, V-1's work on number 1 can be seen in Figure 3 part 1c, it can be seen that the subject can carry out the problem solving plan in accordance with the plan made, so it can be concluded that the visual learner is again able to carry out the problem solving plan well. Then at the stage of rechecking the answers of the visual learner, V-1's work on number 1 can be seen in Figure 3 part 1d, it can be seen that the subject can recheck the answers that have been obtained and make conclusions, so it can be concluded that in problem number 1 the visual learner is able to recheck the answers well.

In the auditory learning style, the ability to solve science problems precisely at the stage of understanding the problem, question 1 in figure 1 produces the results of the problem solving ability test of subject A-1 related to the stage of understanding the problem can be seen in Figure 4.


1. a. Memiliki sebuah jam antik yang memanfaatkon periode gerak ayunan bandul untuk gerakan mesin jamnya (3)
•) memiliki tiga buah bandul
•) memiliki tiga buah tali : 30 cm, 40 cm dan 50 cm

B. cara yang harus digunakan :
Rumus = $T \frac{t}{n}$ → Rumus untuk mencari periode. (3)

C. 1) $T \frac{t}{n}$ $= T \frac{19}{13}$ $= 1,3$ s
2). $T \frac{t}{n}$ $= \frac{21}{10}$ $= 2,1$ s
3). $T \frac{t}{n}$ $= \frac{32}{10}$ $= 3,2$ s (3)

d. Semakin kecil panjang tali akan mempercepat gerakan bandul jam antiknya, yang harus dilakukan oleh ahmad adalah memperkecil panjang tali agar mempercepat gerak bandul jam antiknya. (1)

Figure 4. Subject A-1 work on Problem Number 1

Combining the results of A-1's answers with interview excerpts with A-1 and A-2, it can be seen that the subjects were able to mention that they knew that the rope came from three pendulums of different lengths, and were able to show completely what was asked in question number 1. Furthermore, when viewed from the stage of planning problem solving from the auditory learning style perspective, it can be seen that in question number 1 in Figure 4, Part 1b, A-1, the subject was able to mention the plan used in solving the problem, namely using the formula period = t/n. Therefore, it can be concluded that subjects with auditory learning styles are able to plan problem solving well in problem number 1. The next stage is implementing the plan of the auditory learning style, and by looking at the results of A-1's work at number 1 in Figure 4, Part 1c, it can be seen that the subject is able to carry out the problem solving plan according to the plan made. Therefore, it can be concluded that the auditory learning style is able to carry out the problem solving plan well in number 1. The next stage is to re-examine the completion of the auditory learning style and the performance of subject 1, namely A-1, can be seen in part 1d of figure 4. From the statements of subjects A-1 and A-2, it can be seen that they did not recheck their answers, but made conclusions and showed low accuracy. From these results, it can be concluded that in question number 1, auditory learning styles are less able to recheck answers well.

In the kinesthetic learning style of science problem solving ability, precisely the stage of understanding the problem, question 1 in figure 1 produces the results of the K-1 subject's problem solving ability test related to the stage of understanding the problem can be seen in Figure 5.

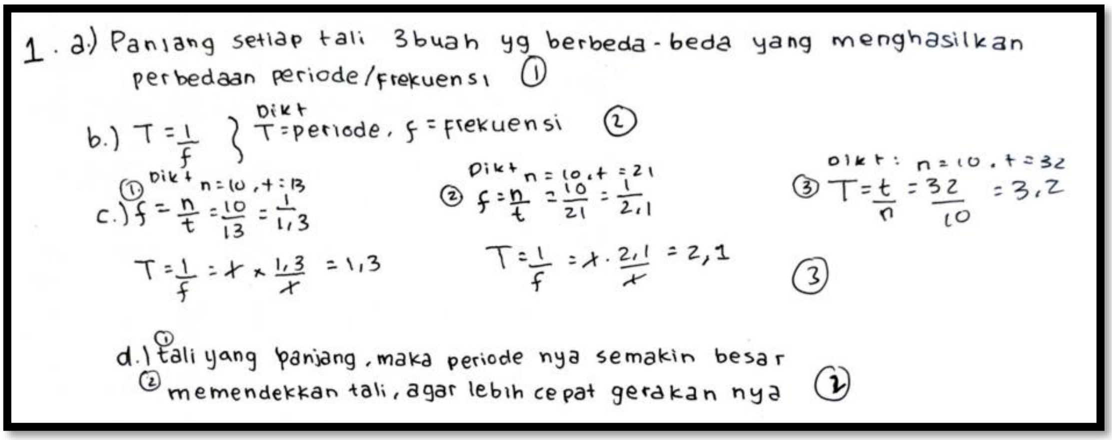


Figure 5. Subject K-1 work on Problem Number 1

Combined from the results of the work of subject K-1 and interview excerpts with K-1 and K-2, it can be seen that the subject did not write and mention all of what was known in problem number 1 and the subject had difficulty in understanding the information so it took a relatively long time. Therefore, kinesthetic learning style subjects are less able to understand the problems given. Furthermore, when viewed from the planning stage of problem solving in terms of kinesthetic learning style, the results of K-1's work on number 1 show that the subject can refer to the plan used in problem solving, namely by using the formula period = 1/f, as shown in part 1b of Figure 5. Therefore, it can be concluded that in problem number 1 the kinesthetic learning style is able to plan problem solving well. Figure 5, Part 1c shows that K-1 is able to implement the problem solving plan that has been formulated. From this it can be concluded that in problem 1 the kinesthetic learning style successfully implemented the problem solving plan. Furthermore, looking at task 1 for K-1 in terms of the kinesthetic learning style answer rechecking index, it can be seen that the subject did not recheck the answers given and came to the conclusion as shown in Figure 5, part 1d which indicates that the subject is less accurate.

Therefore, it can be concluded that in problem number 1 the kinesthetic learning style is not able to recheck the an swer properly. In summary, the results of the analysis of problem solving abilities in students' learning styles based on Polya's stages can be seen in Table 7.

Table 7. Results of Science Problem Solving Ability Based on Learning Style

Learning Style	**Stages of Problem Solving Ability**			
	1 (Problem Identification)	**2 (Planning/Strategy)**	**3 (Implementation)**	**4 (Evaluation/Conclusion)**
Visual	Able	Able	Able	Able
Auditory	Able	Able	Able	Not Able
Kinesthetic	Less Able	Able	Able	Not Able

The stages in solving science problems consist of three stages, namely understanding the problem, planning to solve the problem, implementing the problem solving plan and checking the answer again. The results of the level of science problem solving ability seen based on these four stages show a low category in all indicators. In the indicator of understanding the problem, the majority of students answer what is known and asked from the problem but incorrectly and incorrectly. Errors in writing what is known and asked can occur because students do not understand the questions asked, this will affect the results of their problem solving. If students at the stage of understanding the problem students are still less able will result in failure to identify problems so that it can have an impact on the results of problem solving (Pristianti & Prahani, 2022).

In the indicator of planning problem solving, the majority of students are able to write a problem solving plan in the form of a formula but cannot explain physics symbols. The inability of students to explain the symbols used shows that they do not understand the problem solving plan written down, this has an effect in developing problem solving skills. According to Hermawati, Jumroh, and Sari (2021), the method used to develop students' problem solving ability is to give them experience solving other problems. In the problem solving indicators, the majority of students were able to perform calculations using everything needed, including the right concepts and formulas, but were still wrong in applying the formulas they used. This condition indicates that the learning has not been in-depth so that students only memorize formulas without understanding more deeply. When students have understood the correct formula, there needs to be in-depth learning so that the final answer is also correct (Pristianti & Prahani, 2022). Meanwhile, in the indicator of science problem solving ability, namely checking the answer again, the majority of students can check the answer again but cannot conclude it. This indicates that students cannot apply their answers to the problem so they cannot justify their findings. According to Menurut Hermawati, Jumroh, and Sari (2021) after the solution is found, students must apply it to the problem and explain the solution again, regardless of whether the problem conditions are actually found.

The results that have been presented show that students with visual learner are able to carry out all stages of problem solving. Students with auditory learning styles are able to carry out the problem solving stage except for the stage of checking the answer again. Students with kinesthetic learning styles can carry out the stages in problem solving, namely the planning stage of problem solving and carrying it out, at the stage of understanding the problem they are less able and unable to at the stage of checking the answer again. The following is a discussion related to these results.

Visual learning subjects at the stage of understanding the problem, students are able to understand information correctly. Visual learning subjects have this ability because they easily understand information by reading, especially if there are interesting visualizations. According to Inayah & Masruroh (2021) visualization allows students to interact, respond, and communicate so that they can easily remember information. visual learner prioritizes the sense of sight in learning, where they will quickly understand a problem and absorb information by looking at text, tables, and other research (Irawati, Nasruddin, et al., 2021; Almeida & Cunha, 2020). Dual code learning theory also explains that students will receive information well if they have verbal and visual information processing (Haiza Hayati Baharudin et al., 2021; Agustina et al., 2022; Kanellopoulou & Kermanidis, 2019). Auditory learning subjects in the first stage were also able to understand the problem, because in working on the problem auditory subjects could listen to the explanation that the researcher conveyed regarding what was asked in the problem. Nuralan et al., (2022) stated that auditory learning styles learn by utilizing their sense of hearing, where they can understand information if it is read aloud and read aloud. Subjects with kinesthetic learning styles on understanding the problem are less able to write it down completely. Kinesthetic learning subjects cannot absorb all the information provided if only from writing or explanations from researchers, because the learning process that does not relate to physical activities or activities is less preferred by kinesthetic learning subjects. Kinesthetic learning styles receive and understand information through movement or touch, they develop by doing physical activities (Putri et al., 2019). Behavioristic theory also explains that the learning process requires experience, practice, and training so that it can become a habit that is mastered by each individual (individu (Pratama, 2019; Silva & Kwon, 2020; Efgivia, Ardiansyah, et al., 2021).

In the second stage, namely planning problem solving. Visual learning subjects are able to find the right formula in solving problems, because the subject understands the coherent presentation of text and presentation using graphs or images provided by researchers. Nuralan et al., (2022) state that students visual learner are better at remembering information through what they see in a neat and orderly manner. Paivio's dual code theory shows that presenting information in different forms, visual and verbal can produce strong memory traces, so it can improve student understanding more than just using text (Wang & Wu, 2022; Hayikaleng, 2019; Ain & Pervaiz, 2023; Samburskiy, 2020). Auditory learning subjects are also able to write down the right formula in planning problem solving, because when learning auditory subjects actively ask questions so that when working on a problem they can easily determine the right solution. This is in line with Setiana & Purwoko (2020) which states that auditory learning styles tend to be active in class by asking a lot of questions and like to discuss with friends. This makes them easy to remember when learning. Constructivism learning theory emphasizes that in learning students must build their own knowledge through active involvement in the learning process in class (Sidik, 2023; Bell & Bell, 2020; Shah, 2019). Kinesthetic learning subjects are also able to write down the right formula in solving problems, because by doing activities related to the problem, they can write down planning problem solving in their own words. Students with kinesthetic learning styles write down the problem solving plan that will be used in their own sentences (Setiyadi, 2020).

In the third stage, visual subjects can carry out plans to solve problems using the plans that have been found. At this stage, the subject can interpret the existing plan in the problem solving process. This is in line with Wilujeng & Sudihartinih (2021) which states that visual learning styles have superior interpretation abilities. Auditory learning subjects are also more likely to be able to apply problem solving plans with existing plans, write down given problems in the form of mathematical sentences, and solve problems with predetermined strategies. This is in line with the research of Adawiyah et al., (2020) which states that auditory learning styles like to talk, discuss, and explain things at length. The theory of constructivism also explains that learning is significantly influenced by their interaction with peers which means in the process of communication or discussion (Sayaf, 2023; Rullis et al., 2019; Efgivia et al., 2021; Muhajirah, 2020). Kinesthetic learning subjects are also able to carry out problem solving plans from the plans that have been made, where the subject answers by writing mathematical sentences and writing formulas to solve problems. Al-hamzah & Awalludin (2021) stated that the kinematic learning style in the problem solving phase allows calculations to be carried out by operating formulas and completing steps.

The last stage is checking the answer again. Visual learning subjects were able to rewrite the answers equally and precisely and were able to make conclusions, so with this the subject was confident in the answers he wrote. Auditory and kinesthetic subjects were unable to recheck the answer, the subject only wrote a conclusion but it was also less precise. This inability is based on a lack of understanding of the problem and the calculations made, so they are not sure in writing back the answer. Auditory and kinesthetic learning styles are less able to check all the information and calculations involved, and are unable to evaluate whether the procedures applied and the results obtained are correct (Nurdiana et al., 2021).

Impact of Learning Styles on Problem Solving

The impact of learning styles on problem-solving is a significant aspect of educational psychology that has garnered attention in recent years. Learning styles refer to the individual differences in the way people prefer to learn and process information. These preferences can be categorized into different modalities, such as visual, auditory, and kinesthetic learning styles. Understanding how these learning styles influence problem-solving can offer valuable insights into how to enhance learning outcomes for students across various disciplines.

Research indicates that learning styles play a crucial role in shaping how students approach and solve problems (Pratiwi et al., 2021; Soenarjadi, 2020). Visual learners tend to excel at tasks that require the interpretation of diagrams, charts, and other visual representations. They are better equipped to absorb information through images, graphs, and written content. This style of learning benefits students when they are tasked with solving problems that demand the use of visual aids. For instance, in subjects like mathematics or science, where graphs and diagrams are essential to understanding complex concepts, visual learners often perform better.

In contrast, kinesthetic learners thrive on hands-on activities and learn best through physical movement and touch. These learners are more likely to excel in environments where they can engage with physical materials or simulate real-world scenarios. For example, in subjects like engineering or physical education, where students are required to apply theoretical knowledge in practical settings, kinesthetic learners tend to outperform other learners. Their ability to manipulate objects and engage in physical activities helps them better understand and solve problems that require practical application.

Auditory learners, on the other hand, learn best through listening and verbal communication. They tend to excel in environments where lectures, discussions, and oral instructions play a significant role in the learning process. However, auditory learners may struggle in tasks where visual or kinesthetic methods are more beneficial. For example, in a science class where diagrams or physical experiments are central to problem-solving, auditory learners might find it challenging to grasp the material without appropriate auditory support.

The findings of the study revealed that despite the differences in learning styles, low performance was observed across all groups. This suggests that there may be a mismatch between the nature of the tasks and the students' preferred learning styles. While prior research (Setiyadi, 2020; Kulsum & Kristayulita, 2019) suggests that visual learners often perform better in problem-solving tasks, the current study indicated that performance was low across all learning styles. This indicates that learning activities may not be aligned with students' diverse needs. It highlights the importance of recognizing that learning styles are not the sole determinant of performance. Rather, a more holistic approach to teaching, which incorporates a variety of learning methods and strategies, may be necessary to ensure that all students are provided with the optimal environment to succeed.

The current research emphasizes the need for educators to carefully consider the learning styles of their students when designing problem-solving tasks. A one-size-fits-all approach to teaching may not be effective for all learners. Instead, tailoring tasks and materials to accommodate different learning styles can improve engagement and problem-solving skills. For instance, teachers could combine visual aids, hands-on activities, and oral instructions in a way that provides a more inclusive learning experience. This approach would allow students to engage with the material in ways that align with their preferred learning styles, ultimately enhancing their ability to solve problems effectively.

The Impact of External Factors: Classroom Environment and Teaching Methods on Problem Solving

External factors, such as classroom environment and teaching methods, significantly influence how students approach and solve problems. The classroom environment, including both physical and psychological aspects, can either facilitate or hinder students' cognitive engagement and problem-solving abilities. A well-organized and comfortable classroom with adequate lighting, seating arrangements, and resources encourages students to focus and actively participate in problem-solving tasks. A positive psychological environment, where students feel safe, supported, and motivated, fosters a growth mindset and resilience in tackling challenging problems. Conversely, a disruptive or uncomfortable classroom setting may lead to disengagement and hinder cognitive processing, thus reducing problem-solving performance.

Teaching methods also play a crucial role in shaping students' problem-solving strategies. Traditional methods, such as lectures and direct instruction, may not fully engage students or encourage independent thinking. In contrast, more interactive and student-centered teaching methods, such as collaborative learning, project-based learning, and inquiry-based learning, stimulate critical thinking and problem-solving skills. These methods encourage students to work together, apply theoretical knowledge to real-world scenarios, and develop a deeper understanding of the material. Furthermore, incorporating diverse teaching strategies that cater to different learning styles—visual, auditory, and kinesthetic—can enhance problem-solving abilities by allowing students to engage with the material in ways that align with their preferences.

Comparison of Learning Styles

The study utilized a questionnaire adapted from O'Brien (1985) to categorize students' learning styles into visual, auditory, kinesthetic, and visual-kinesthetic. The results reveal a dominance of kinesthetic learners (58%), followed by visual learners (25%) and auditory learners (13%). The small percentage of visual-kinesthetic learners (4%) limits the generalizability of results for this group, highlighting the unique characteristics of kinesthetic learners that may not align with other styles. Further analysis of science problem-solving abilities shows that the majority of students (71%) scored low in their problem-solving tasks, with only 8% performing at a high level. The results reflect a need for tailored teaching methods that account for diverse learning styles, as learning styles can significantly influence students' ability to solve problems. Specifically, visual learners may excel in tasks requiring interpretation of visual data, kinesthetic learners may perform better in hands-on tasks, and auditory learners may face challenges in visual or kinesthetic-focused activities. Additionally, the study investigates how students with different learning styles perform across the stages of problem-solving, including problem identification, planning, implementation, and evaluation. The visual learner showed a good grasp of understanding problems, planning, and implementing solutions but struggled slightly with rechecking answers. Auditory learners demonstrated strengths in understanding the problem and planning but faced difficulties during the evaluation stage. Kinesthetic learners struggled with problem identification and evaluation but performed well in planning and implementing solutions.

CONCLUSION

Based on the results and discussion, it can be concluded that 1) There are four types of student learning styles namely visual, auditory, kinesthetic and visual-kinesthetic and the majority have a kinesthetic learning style with a total of 14 students out of 23 students. 2) Based on the average score of the science problem solving ability test, it shows that the level of students' science problem solving ability is low. 3) Students visual learner are better able to understand the problem, plan the solution, implement the plan, and recheck the answer; students with auditory learning styles are better able to understand the problem, plan the solution, implement the plan, but cannot recheck the answer, which is the fourth step; students with kinesthetic learning styles are less able to understand the problem, plan problem solving, implement the plan well, but cannot recheck the answer which is the fourth step. This can show that students with visual learning styles tend to be better at solving problems than students with auditory and kinesthetic learning styles. Therefore, a more practical implication for teachers is to adjust teaching methods and problem-solving activities according to students' learning styles.

RECOMMENDATION

While the study sheds light on the impact of learning styles on students' problem-solving abilities, the findings also highlight the need for practical educational strategies. The conclusion emphasizes the importance of recognizing students' learning styles in the development of effective learning models, but does not provide concrete recommendations for educators on how to address these differences in the classroom. Therefore, a more practical implication for teachers is to tailor teaching methods and problem-solving activities according to the learning styles of students. Teachers should undergo training to recognize and accommodate various learning styles in their classrooms. Professional development programs focused on differentiated instruction and active learning methods can equip teachers with the skills necessary to support diverse learning preferences. By becoming more familiar with the characteristics of different learning styles, teachers can enhance their ability to adjust their teaching strategies accordingly. For instance, visual learners could benefit from more diagrams and written instructions, auditory learners might excel in discussions and verbal instructions, while kinesthetic learners could engage in hands-on activities and physical demonstrations. The study calls for future research, but the recommendations for further studies remain vague. More specific suggestions are needed for future investigations on how to integrate specific teaching methods and materials that cater to different learning styles in order to improve science problem-solving abilities. Future studies could explore how particular learning models, such as project-based learning or inquiry-based learning, can be adapted to match the learning styles of students, and how these approaches can enhance the problem-solving process in science education.

ACKNOWLEDGMENT

The researcher would like to express gratitude to all those who have contributed to the success of this research. Special thanks to Miss Nailil Inayah, S.Pd., M.Pd., for guiding and supporting the research process. Also, thanks to the lecturers who have helped review this research. Heartfelt thanks go to the VII A students and teachers of SMPN 3 Surabaya who participated in the research. Without their cooperation and openness, this research would not have been possible.

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