

Analysis of student errors in solving statistics questions visited from learning style

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Abstrak

Diiringi kemajuan teknologi analisis data modern, Melimpahnya data sosial dalam revolusi industri 4.0 memotivasi para pendidik untuk memasukkan prinsip-prinsip statistika ke dalam pembelajaran di kelas. Soal-soal yang mencakup materi statistika masih sulit untuk dipecahkan oleh para siswa, menurut penelitian sebelumnya. Penelitian ini bertujuan untuk mengetahui jenis kesalahan yang dilakukan oleh siswa dalam menyelesaikan soal statistika berdasarkan gaya belajar (visual, auditori, dan kinestetik). Siswa kelas sembilan di SMP Darussalam Tegal Joyo berpartisipasi dalam penelitian ini, yang menggunakan metodologi deskriptif kualitatif. Hasil penelitian ini menunjukkan bahwa 1. pelajar visual melakukan kesalahan dalam konseptual dan prosedur dalam hal ini mereka tidak memahami konsep rata-rata gabungan, sehingga rumus yang mereka gunakan ketika menyelesaikan soal kurang tepat dan cara menghitung kelas median tidak memakai frekuensi kumulatif. 2. Pelajar auditori melakukan kesalahan konseptual dan prosedural, mereka salah memahami konsep rata-rata gabungan dan juga gagal menggunakan frekuensi kumulatif untuk mendapatkan kelas median. 3. Peserta kinestetik melakukan kesalahan prosedur dengan tidak menggunakan frekuensi kumulatif untuk mendapatkan kelas median.

Keyword: analisis kesalahan, statistika, gaya belajar.

Abstract

Accompanied by advances in modern data analysis technology, the abundance of social data in the industrial revolution 4.0 motivates educators to incorporate statistical principles into classroom learning. Questions covering statistical material are still difficult for students to solve, according to previous research. This research aims to determine the types of errors made by students in solving statistics problems based on learning styles (visual, auditory and kinesthetic). Ninth grade students at SMP Darussalam Tegal Joyo participated in this research, which used a qualitative descriptive methodology. The results of this research show that 1. visual learners make conceptual and procedural errors in this case they do not understand the concept of combined average, so the formula they use when solving problems is not precise and the way to calculate the median class does not use cumulative frequency. 2. Auditory learners make conceptual and procedural errors, they misunderstand the concept of compound average and also fail to use cumulative frequency to obtain median class. 3. Kinesthetic participants made a procedural error by not using cumulative frequency to get the median class.

Keyword: error analysis, statistics, learning styles.

INTRODUCTION

Mathematics is a scientific method that is the basis of all technological efforts and has a significant impact on the development of human intelligence. Studying mathematics is a great way to sharpen your analytical thinking skills. According to (Herwidi & Jumroh, 2024), students can bridge the gap between logical, critical, creative and methodical thinking in mathematics because this subject evolves and develops through the thinking process. When it comes to teaching students how to think critically and reason deductively, mathematics plays an important role in the field of education. Therefore, students must start studying mathematics in elementary school and continue studying until college (Mahmudah et al., 2022).



According to (Kusumarini & Dhoruri, 2024), the stated aim of mathematics education is to help students become more resilient and able to adapt to a dynamic and unpredictable world by teaching them to think critically, rationally, honestly and efficiently. According to the Ministry of National Education, students should be able to do the following things after they complete secondary school mathematics: first, the ability to understand and apply concepts; second, the ability to convey mathematical concepts using symbols, tables, diagrams, or other media to explain situations or problems; ability to generalize, explain, and apply ideas effectively, precisely, and flexibly; and the ability to solve problems. For the fourth aim, the Ministry of National Education says that students should be able to explain complex situations or difficulties using visual aids such as tables, diagrams and symbols, and statistical research is often carried out in accordance with this aim. Standard content of Minister of Education and Culture Regulation no. 8 of 2024 states that SMP/MTs students are required to take statistics subjects as part of their mathematics education. This course includes learning about how to interpret data through various types of data displays and how to measure data centrality.

Curriculum development aims to incorporate statistical ideas into the school curriculum, which is facilitated by the current development of data analysis technology and the abundance of social data in the industrial era 4.0 (Sari & Bernard, 2020). According to (Santika, 2022), several advantages of statistics include: 1) getting a clearer picture of a phenomenon by using statistical measures; 2) draw conclusions from the population sample with full confidence; 3) make money through sampling; and 4) fix the problem. We can now state that statistics has had an impact on every scientific discipline, from linguistics to astrophysics. Statistics has influenced engineering in many fields, including biology, economics, and psychology. These real-world applications of statistics highlight the critical need for students to master the subject as a basis for moving on to other courses that use statistical ideas.

Students still have difficulty answering questions that contain statistical content, according to research (Febrianti & Chotimah, 2020). Statistics homework continues to confuse students because they still don't fully understand the material and are not good at answering questions accurately. Apart from that, students still have difficulty understanding the statistical questions given, according to research (Mediyani & Mahtuum, 2020). According to study findings (Mediyani & Mahtuum, 2020), only five students answered 69% of the questions correctly, and no one answered them all correctly.

Statistics teachers need a way to point out their students' mistakes if they want to improve their students' performance in the subject. Teachers are obliged to check student errors in solving questions and formulating answers. The goal of this exercise is to help teachers identify common mistakes made by students and the factors that cause them (Kopfer, 2022). With this information, they can then work together with their students to develop effective strategies for learning. This is in line with the opinion of (Ovinka & Hartati, 2020) which states that it is important to study students' errors in problem solving to identify their sources and develop strategies to correct them.

Students often make various kinds of mistakes (Simpson et al., 2020; Buteler & Coleoni, 2009). Some of them are based on Kastolan's works. Conceptual, procedural and technical errors are three types of errors that may occur in mathematics learning, according to Kastolan (Hakim & Ramlah, 2021). Technical errors occur when students fail to pay attention to calculations, procedural errors occur when students make errors in procedures and systematic approaches to solving mathematical problems, and conceptual errors occur when students make errors in their understanding of the ideas involved.

There are often several factors that play a role when students make mistakes when solving math problems. This is in line with the findings of (Safitri et al., 2021) who found that learning style is one of the factors that contributes to student errors in learning. Every student is different, especially when it comes to the learning methods they choose. This is in line with Sudjana's research findings (Aly et al., 2019), which emphasizes that learning is intrinsically linked to each student's unique learning style. Not only do students have varying processing speeds, but they also learn at varying rates. Teachers can take advantage of this variation to implement learning models that encourage student independence and knowledge construction (Jamaluddin et al., 2013). Teachers can help their students better understand course material and make fewer mistakes if they know their preferred learning style (Yofita et al., 2022).

A person's learning style is the way they prefer to receive and understand data from the surrounding environment (Susanto et al., 2018). Learning style has an important role in the learning process. This highlights the importance of students being aware of and feeling comfortable with their respective learning styles, and teachers also need to pay attention to students' learning styles so that learning can take place effectively and efficiently. Deporter and Hemacki (Febryana et al., 2023) divide learning styles into three types: visual, auditory, and kinesthetic. With this classification, it is hoped that teachers can pay special attention to the needs of each student, considering the importance of learning

styles in supporting the learning process. So based on this background, the researcher wants to find out the mistakes students make in solving statistics problems in terms of their learning style.

METHOD

This research uses a qualitative descriptive approach. Ninth grade students at SMP Darussalam Tegal Joyo participated as research subjects. One child who learns best through sight, one child who learns best through sound, and one child who learns best through movement become research subjects. Research data was collected through administering questionnaires, tests and interviews. Researchers sorted students into groups based on their preferred learning methods by giving them surveys. Researchers obtained information about students' study habits through interviews and exams while studying statistics challenges. After that, researchers used a time triangulation approach to ensure the correctness of the data. The combination of time adjustments on interview questions and written exam scores makes this possible.

Kastolan's three branches of theory, namely conceptual, procedural and technical, are the basis for error analysis. According to Kastolan (Hakim & Ramlah, 2021), there are three types of errors that may occur in mathematics learning, namely conceptual, procedural and technical errors. Conceptual errors include students' understanding of the underlying ideas, procedural errors center on students' methods and systems for solving problems, and technical errors occur when students lose concentration during calculations.

Table 1. Errors According to Kastolan

Error type	Indicator
Conceptual	Errors related to students' understanding of the concepts used
Procedure	Errors that focus on students' steps and systematics in solving mathematical problems
Technical	Errors that occur if students do not pay attention to calculations

The data analysis technique in this research was carried out in three stages, including: data reduction, data presentation, and drawing conclusions.

RESULTS AND DISCUSSION

According to (Rahmawati & Gumindari, 2021), the learning process will run more smoothly and efficiently if the approach used is adapted to each student's learning style. However, other factors, such as students' unique skills, interests, emotions, and personalities, can influence how well they remember the material. However, it cannot be denied that students' learning methods significantly influence their understanding of the material. This is because each student's learning style is unique and reflects their personality. The following is data from the identification of learning styles of class IX students at SMP Darussalam Tegal Joyo which became the researcher's reference in determining research subjects.

Table 2. Number of class IX students at SMP Darussalam Tegal Joyo

Student Learning Style	Number of Students
Visual	8
Auditory	2
Kinesthetic	7
Total number of students	17

In table 2, the majority of ninth grade students clearly learn best through visual means. Next, the researchers used the findings from identifying learning types to select three subjects: one who learned best visually, one who learned best auditorily, and one who learned best kinesthetically.

Analyze test results for each learning style

1. Subject Visual Learning Style (SV)

- a. The following is a discussion of the results of the first stage of the visual learning style subject test

$$1) \begin{array}{r} 45 + 35 \\ \hline 80 \end{array} \quad \begin{array}{r} 80 \\ \hline 2 \\ \hline 40 \end{array}$$

Figure 1. Answers to SV Test question number 1 first stage

Based on Figure 1, the results of the first stage of the test on question number 1, it is clear that the subject made a conceptual error. The subject made a conceptual error by not understanding the concept of combined average. Where the subject only wrote down the average body weight of male students added to the average weight of female students, then divided by the number two.

$$F = 2 + 6 + 9 + 12 + 20 + 11 = 60$$

$$N = 60 \cdot \frac{N}{2} = \frac{60}{2} = 30 \cdot \frac{N}{2} + 1 = \frac{60}{2} + 1 = 15 + 1 = 16$$

Jadi media terletak di
tinggi badan 149

Figure 2. Answers to SV Test question number 2, first stage

Based on Figure 2, the results of the first stage of the test on question number 2, it is clear that the subject made a procedural error. The subject made a procedural error by not using the cumulative frequency to determine the median class.

- b. The following is a discussion of the results of the second stage of the visual learning style subject test

$$1) \begin{array}{r} 70 + 95 \\ \hline 165 \end{array} \quad \begin{array}{r} 165 \\ \hline 2 \\ \hline 82.5 \end{array}$$

Figure 3. Answers to SV Test question number 1 second stage

Based on Figure 3, the results of the second stage of the test on question number 1, it is clear that the subject made a conceptual error. Because respondents were unfamiliar with the idea of a composite average, they committed conceptual errors. In the section where the subject writes the average mathematics test results of male and female students, divided by two.

$$2) F = 5 + 12 + 15 + 8 = 40$$

$$N = 40 \cdot \frac{N}{2} = \frac{40}{2} = 20 \cdot \frac{N}{2} + 1 = \frac{40}{2} + 1 = 10 + 1 = 11$$

Jadi media terletak di
ukuran sepatu 37

Figure 4. Answers to SV Test question number 2 second stage

Based on Figure 4, the results of the second stage of the test on question number 2, the subject clearly made a mistake in following the correct procedure. By not calculating the class median using cumulative frequencies, the subject committed a procedural error. Based on the findings from the first and second stages of triangulation, as well as discussion, it was concluded that the findings were valid because they had the same or consistent trend. The results showed that those who learn best visually are less likely to make errors in conceptual and procedural areas.

2. Subject of Auditory Learning Style (SA)

- a. The following is a discussion of the results of the first stage of the auditory learning style subject test

$$1. = \frac{45 + 35}{2} : \frac{80}{2} : 40$$

Figure 5. SA Test answer to question no. 1 first stage

Based on Figure 5, the results of the first stage of the test on question number 1, it is clear that the subject made a conceptual error. The subject made a conceptual error by not understanding the concept of combined average. Where the subject wrote down the average body weight of male students added to the average weight of female students, then divided by the number two.

$$2. \text{ frekuensi : } 1 + 6 + 9 + 12 + 20 + 11 : 60, N = 60 \frac{N}{2} = \frac{60}{2} = 30, \frac{N}{2} + 1 = \frac{60}{2} + 1 = 31$$

= Jadi frekuensi dimedial terletak di tinggi badan : 149

Figure 6. Answers to SA Test question number 2, first stage

Based on Figure 6, the results of the first stage of the test on question number 2, it is clear that the subject made a procedural error. The subject made a procedural error by not using the cumulative frequency to determine the median class.

- b. The following is a discussion of the results of the second stage of the auditory learning style subject test

$$1. \frac{70 + 95}{2} : \frac{165}{2} : 82.5$$

Figure 7. SA Test answer to question no. 1 second stage

Based on Figure 7, the results of the second stage of the test on question number 1, it is clear that the subject made a conceptual error. The subject made a conceptual error by not understanding the concept of combined average. Where the subject wrote down the average math test score for male students added to the average math test score for female students, then divided by the number two.

$$2. \text{ frekuensi : } 5 + 12 + 15 + 8 : 40$$

$$N = 40 : 40 \frac{N}{2} = \frac{40}{2} = 20, \frac{N}{2} + 1 = \frac{40}{2} + 1 = 21$$

= Jadi frekuensi dimedial terletak di tinggi badan ukuran sepatu : 37

Figure 8. SA Test answer to question no. 2 second stage

Based on Figure 8, the results of the second stage of the test on question number 2, it is clear that there was a procedural error made by the subject. The subject made a procedural error because he did not calculate the median class using cumulative frequency. Therefore, this is considered valid because the findings from the first and second stages of triangulation, in addition to the explanations provided, show that they have the same or consistent tendency. The research results show that those who learn auditorily tend to make mistakes in conceptual and procedural.

3. Subject Kinesthetic Learning Style (SK)

- a. The following are the results of the discussion of the first stage of the kinesthetic learning style subject test

- Jawaban Rumus: $\bar{X} = \frac{n_1 \times \bar{X}_1 + n_2 \times \bar{X}_2}{n_1 + n_2}$

$$1. \frac{10 \times 45 + 15 \times 35}{10 + 15} = \frac{450 + 525}{25} = \frac{975}{25} = 39 //$$

Figure 9. SK Test answer to question no. 1 first stage

Based on Figure 9, the results of the first stage of the test on question number 1, it is clear that the subject understands the concept of combined average, the subject is also correct in carrying out calculation operations.

2. 2 + 6 + 9 + 12 + 20 + 11 = 60
 $N: 60, \frac{N}{2} = 30, \frac{N}{2} + 1 = 31$
 Karena frekuensi terbanyak terdapat pada berat badan 19 maka medianya terdapat pada 19,,

Figure 10. SK Test answer to question no. 2 first stage

Based on Figure 10, the results of the first stage of the test on question number 2, it is clear that the subject made a procedural error. The subject made a procedural error by not using the cumulative frequency to determine the median class.

4. The following are the results of the discussion of the second stage of the kinesthetic learning style subject test

- Jawaban

1. Rumus: $\bar{X} = \frac{n_1 \times \bar{X}_1 + n_2 \times \bar{X}_2}{n_1 + n_2}$

$$= \frac{12 \times 70 + 8 \times 95}{12 + 8} = \frac{840 + 760}{20} = \frac{1.600}{20} = 80 //$$

Figure 11. SK Test answer to question no. 1 second stage

Based on Figure 11, the results of the second stage of the test on question number 1, it is clear that the subject understands the concept of combined average, the subject is also correct in carrying out calculation operations.

2. $5 + 12 + 15 + 8 = 40$
 $N : 40, \frac{N}{2} = \frac{40}{2} = 20, \frac{N}{2} + 1 = \frac{40 + 1}{2} = 21.$
NB: karena frekuensi paling banyak terdapat pada ukuran sepatu (37) maka median dari data tersebut adalah: 37.

Figure 12. SK Test answer to question no. 2 second stage

Based on Figure 12, the results of the second stage of the test on question number 2, it is clear that the subject made a procedural error. The subject made a procedural error by not using the cumulative frequency to determine the median class. Therefore, this is considered valid because the findings from the first and second stages of triangulation, in addition to the explanations provided, show that they have the same or consistent tendency. The research results show that those who learn kinesthetically tend to make procedural errors.

CONCLUSION

The conclusion of this research indicates that students with different learning styles—namely visual, auditory, and kinesthetic—demonstrated distinct patterns of conceptual and procedural errors in solving statistical problems, particularly those involving measures of central tendency. Students with visual and auditory learning styles were found to make both conceptual and procedural mistakes. The conceptual errors were characterized by a lack of understanding of the concept of the combined average, suggesting that these students had difficulty grasping how to merge multiple data sets and compute a meaningful overall average. In terms of procedural errors, these students failed to utilize cumulative frequency as a necessary step in identifying the median class, which is essential in grouped data problems.

Meanwhile, the student with a kinesthetic learning style also made a procedural error, specifically by not using cumulative frequency to determine the median class. However, unlike the visual and auditory learners, this student did not display a misunderstanding of the underlying concepts, but rather showed difficulty in executing the correct procedure. This finding highlights that even when conceptual understanding may be intact, procedural lapses can still significantly impact the accuracy of students' mathematical problem solving. Overall, the results suggest that learning styles may influence the types of errors students are prone to make, and thus, tailored instructional strategies that address both conceptual clarity and procedural fluency should be considered to improve learning outcomes in mathematics.

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