



ANALYSIS OF EIGHTH-GRADE STUDENTS' MATHEMATICAL CONNECTION ABILITY IN SOLVING STATISTICS WORD PROBLEMS BASED ON MATHEMATICAL ABILITY

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ABSTRACT

This study aims to analyze students' mathematical connection abilities in solving statistics word problems based on their levels of mathematical ability (high, medium, and low). A qualitative descriptive approach was employed involving eighth-grade students at SMPN 9 Palu. Data were collected through written tests and semi-structured interviews and analyzed using the Miles and Huberman model. The findings reveal qualitative differences in how students construct mathematical connections. High-ability students demonstrate well-structured and flexible connections by integrating statistical concepts, arithmetic operations, and real-life contexts. Medium-ability students are able to establish connections, but these tend to be procedural and lack conceptual depth. In contrast, low-ability students exhibit fragmented understanding and experience difficulties in linking concepts, representations, and real-life applications. This study highlights that mathematical connection ability is closely related to the depth of conceptual understanding rather than merely procedural competence. The novelty of this study lies in revealing distinct patterns of mathematical connections across different ability levels within the specific context of statistics word problems. The findings provide implications for designing instructional strategies that explicitly support the development of mathematical connections in classroom practice.

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1. INTRODUCTION

Mathematical connection is a fundamental process in mathematics learning that enables students to link concepts within mathematics, relate them to real-life situations, and apply them across different fields. These connections are essential for developing a deep understanding of mathematical concepts and for solving contextual problems (Nazaretha et al., 2019; Atmaja et al., 2020)). However, in classroom practice, students often perceive mathematics as fragmented concepts, which leads to difficulties in establishing meaningful connections between ideas (Hidayati & Jahring, 2021).

One type of task that strongly requires mathematical connection is statistics word problems. Such problems demand students to simultaneously interpret data, apply statistical concepts such as mean and data representation, and integrate them with arithmetic operations and real-life contexts (Darmawansyah et al., 2022). However, solving word problems remains a challenge for many students due to the need for analytical thinking and the ability to connect multiple concepts (Dwidarti et al., 2019).

Although research on mathematical connection has been widely conducted, several important limitations remain. Most existing studies tend to examine mathematical connection abilities in general contexts without focusing on specific mathematical content, particularly statistics, which requires the integration of data interpretation, representation, and arithmetic operations (Darmawansyah et al., 2022). In addition, previous studies commonly describe students' connection abilities in a general manner without exploring how these connections differ qualitatively across levels of mathematical ability (Hidayati & Jahring, 2021). Furthermore, studies that specifically investigate mathematical connection abilities in statistics word problems while considering differences in students' mathematical ability levels are still limited (Elanda et al., 2024). As a result, there is still insufficient understanding of the structural characteristics of students' mathematical connections when solving statistical problems.

Addressing these gaps, this study offers a more focused and in-depth analysis of students' mathematical connection abilities by examining not only the presence of connections but also the patterns and characteristics of these connections across different ability levels (high, medium, and low) within the specific context of statistics word problems. The novelty of this study lies in revealing qualitative differences in how students construct, organize, and apply mathematical connections, thereby providing a more detailed perspective on students' conceptual structures that has not been sufficiently explored in previous studies.

Therefore, this study aims to analyze the mathematical connection abilities of eighth-grade students in solving statistics word problems based on their levels of mathematical ability. The findings are expected to contribute to a deeper understanding of students' connection processes and to inform the design of instructional strategies that better support the development of meaningful mathematical understanding.

2. METHOD

This study employs a qualitative approach with a descriptive research design. This approach was chosen because the study aims to provide an in-depth description of students' mathematical connection skills in solving statistical word problems from the perspective of mathematical ability (Creswell, 2018). Qualitative research yields data in the form of written or spoken words from the observed subjects, thereby enabling a contextual description of the phenomenon.

The study was conducted at SMP Negeri 9 Palu, Central Sulawesi, during the 2025/2026 school year. The research subjects were eighth-grade students selected based on their mathematical ability. Subjects were determined based on their daily math test scores; the mean and standard deviation were then calculated to group students into three categories: high, medium, and low ability. The research subjects were determined based on recommendations from the mathematics teacher, taking into account students' learning outcomes and final mathematics examination scores from the previous semester. Accordingly, three students were selected as the participants in this study.

Table 1. Grouping of Students by Ability

No	Category	Criteria	Number of students
1	High ability	$x \geq 73$	6
2	Medium ability	$44,7 \leq x < 73$	18
3	Low ability	$x < 44,7$	6

Information:

x = Students scores

The data in this study consists of qualitative data covering students' ability to: (1) relate mathematical concepts to other mathematical concepts, (2) relate mathematical concepts to everyday life, and (3) relate mathematical concepts to other fields. The primary data source was eighth-grade students at SMPN 9 Palu.

The data collection methods used included written tests and interviews. The written test consisted of descriptive statistical word problems designed based on indicators of mathematical connection skills. The test instrument comprised two items with equivalent characteristics. The interviews used were semi-structured interviews aimed at gaining a deeper understanding of students' thought processes in solving problems.

The research instruments consisted of primary and supplementary instruments. The primary instrument was the researcher, who functioned as both the data collector and data analyst throughout the study (Creswell, 2018; Miles et al., 2014). The supplementary instruments included a mathematical connection test and interview guidelines. Prior to their implementation, the instruments were validated by experts to ensure their validity and alignment with the research objectives (Sugiyono, 2013). The validation process was conducted to evaluate the appropriateness of the instrument content, language clarity, and suitability with the research indicators before the instruments were administered to the participants. The instruments were validated by three experts in mathematics education focusing on content relevance, language clarity, and construct suitability.

The credibility of the data in this study was tested using the time triangulation technique. This technique involved administering two tests and conducting interviews with the subjects at different times. The results from both data collection rounds were compared to ensure the consistency of the data obtained. If any discrepancies were found, data collection was repeated until credible data was obtained.

The data analysis technique follows the Miles and Huberman model, which consists of three stages: data condensation, data presentation, and drawing conclusions (Miles et al., 2014). Data condensation involves selecting and simplifying data relevant to the research objectives. Data presentation takes the form of descriptions of test results and interviews based on indicators of mathematical connection skills. Next, drawing conclusions is done by interpreting the analyzed data to obtain an overview of students' mathematical connection skills.

3. RESULTS AND DISCUSSION

3.1. Results

The subjects selected were the students in Class VIII A at SMPN 9 Palu; this eighth-grade level consists of Classes VIII A through VIII I. The selection of subjects was based on the final semester exam scores in mathematics from 30 students.

Table 2. Grouping of Students by Ability

No	Initials	Value	Ability
1	NA	80	High
2	ADF	65	Medium
3	ABD	38	Low

Based on recommendations from the mathematics teacher which were grounded in the outcomes of the learning process and the final exam scores from the previous semester's mathematics course in Class VIII A three research subjects were selected. These recommendations also took into account the grouping of final exam scores into three categories high, medium, and low ensuring that the selected subjects represented each level of student ability.

This subsection presents an analysis of data on mathematical connection skills, which include the ability to relate one mathematical concept to another, the ability to relate mathematical concepts to everyday life, and the ability to relate mathematical concepts to other fields. The data analysis in this study consists of three components: data condensation, data presentation, and drawing conclusions, as outlined in the previous chapter.

Analysis of Data on High-Ability Students (NA) in Relating One Mathematical Concept to Another

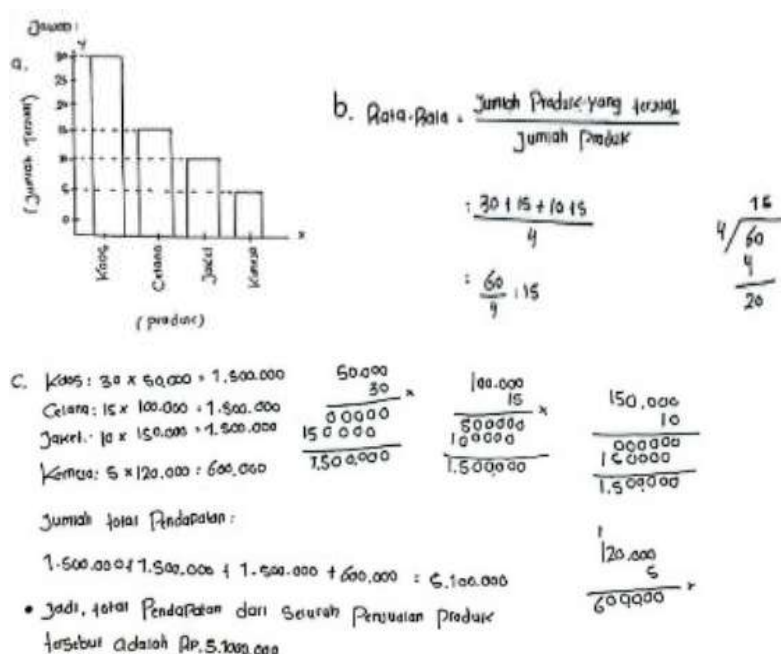


Figure 1. NA Written Test Results in Relating One Mathematical Concept to Another

- FTM1 011 : For part a, how do you create a bar chart?
- NAM1 012 : First, list the products and their sales figures, then draw horizontal and vertical lines with the horizontal line showing the total number of products and the vertical line showing the total sales. Then adjust the chart to reflect the specific products and sales figures.
- FTM1 021 : Could you please explain in more detail what materials and concepts were used to achieve those results?
- NAM1 022 : To solve this, I used the concept of calculating the average, where the sum of the data is divided by the number of products, and then applied the arithmetic operations of addition and division.

Based on the analysis of the written test and interview results, subject NA demonstrated the ability to relate statistical concepts, particularly data presentation, to geometric concepts such as bar charts. NA was able to correctly represent data using axes, scale, and bar placement, and connect statistical concepts with arithmetic operations, including addition, division, and multiplication to determine averages and total revenue. Thus, NA effectively meets the indicator of connecting one mathematical concept to another.

Analysis of Data on High-Achievers (NA) in Relating Mathematical Concepts to Everyday Life

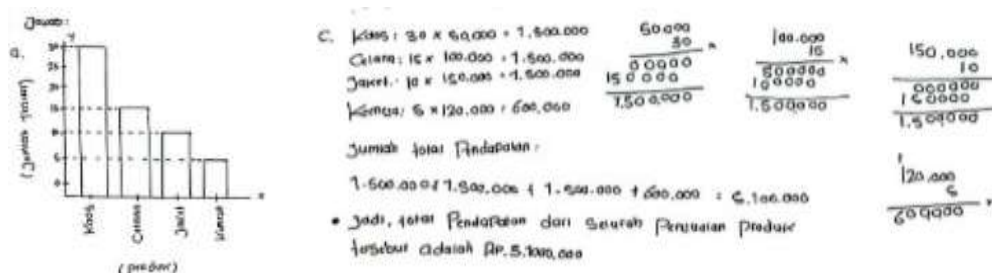


Figure 2 NA Written Test Results in Relating Mathematical Concepts to Everyday Life

- FTM1 011 : For part a, how do you create a bar chart?
- NAM1 012 : First, list the products and their sales figures, then draw horizontal and vertical lines with the horizontal line showing the total number of products and the vertical line showing the total sales. Then adjust the chart to reflect the specific products and sales figures.
- FTM1 013 : Have you ever encountered a situation like this in your daily life? If so, where do you usually find them?
- NAM1 014 : It's like a marketplace. it makes it easier to present data and see which products are selling better.
- FTM1 027 : Okay, regarding part (c), have you ever encountered this in your daily life?
- NAM1 028 : For example, when you hold a school bazaar, you need to calculate the total revenue.

Based on the written test and interview results, subject NA was able to relate statistical concepts, particularly bar chart data presentation, to everyday life by identifying best-selling products and calculating total revenue. Thus, NA meets the indicator of relating mathematical concepts to daily life.

Analysis of Data on High-Achievers (NA) in Relating Mathematical Concepts to Other Fields

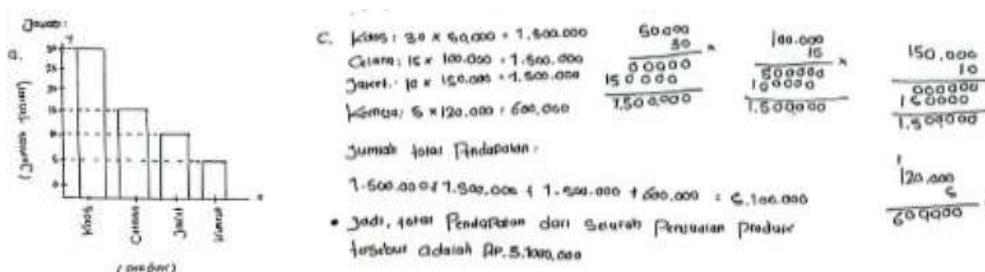


Figure 3 NA Written Test Results in Relating Mathematical Concepts to Other Fields

- FTM1 017 : Besides that, what other fields are related to the information you just explained?
- NAM1 018 : This also relates to the economic sector, to illustrate the sales figures for various products that have been sold
- FTM1 027 : Okay, regarding part (c), have you ever encountered this in your daily life?
- NAM1 028 : For example, when you hold a school bazaar, you need to calculate the total revenue.
- FTM1 029 : What field do questions like this usually related to?
- NAM1 030 : It's also related to economics, you know, when it comes to calculating profits..

Based on the written test and interview results, NA demonstrated the ability to apply statistical concepts, particularly bar chart data presentation, in the field of economics. NA used bar charts to represent sales data and calculated total revenue from product sales. Thus, NA meets the indicator of applying mathematical concepts in other fields.

Analysis of Data on Students of Average Ability (ADF) in Relating One Mathematical Concept to Another.

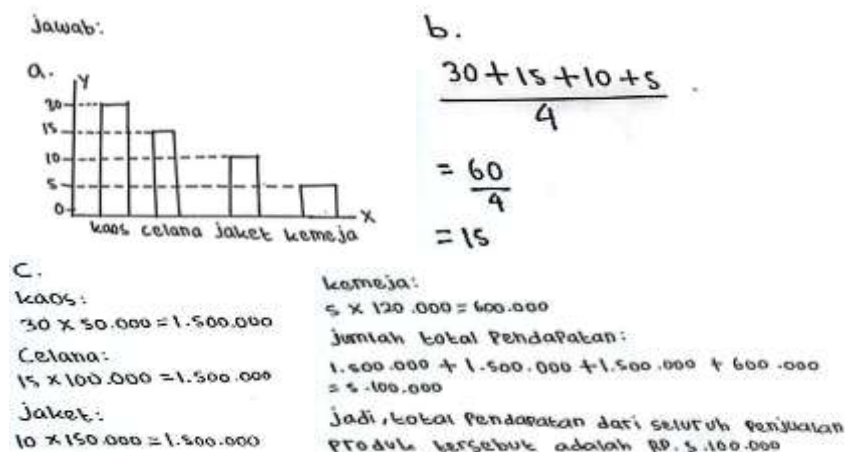


Figure 4. ADF Written Test Results in Relating One Mathematical Concept to Another.

- FTM1 009 : Can you explain how you solved question (a)?
- ADFM1 010 : I drew the x and y axis first, then I arranged the data starting from the largest value, and matched it with the number sold, such as shirts 30, jackets 15, pants 10, and T-shirts 5.
- FTM1 021 : so what was the result?
- ADFM1 022 : I have a total of 60. I divide that by 4, which is the number of finished products, so I use division and get the result 15.
- FTM1 029 : Next, how do you plan to solve this problem?
- ADFM1 030 : I multiplied the number of items by their unit price. I sold 30 T-shirts at 50,000 each, 15 pairs of pants at 100,000 each, 10 jackets at 150,000 each, and 5 shirts at 120,000 each. Then I added up all the results, so the total is 5,100,000 IDR.

Based on the written test and interview results, subject ADF demonstrated the ability to relate statistical concepts, particularly bar chart data presentation, to geometric concepts such as the X and Y axes. ADF was also able to connect statistical concepts with arithmetic operations, including addition, division, and multiplication to determine averages and total revenue. Thus, ADF sufficiently meets the indicator of relating one mathematical concept to another.

Analysis of Data on Students of Average Ability (ADF) in Relating Mathematical Concepts to Everyday Life

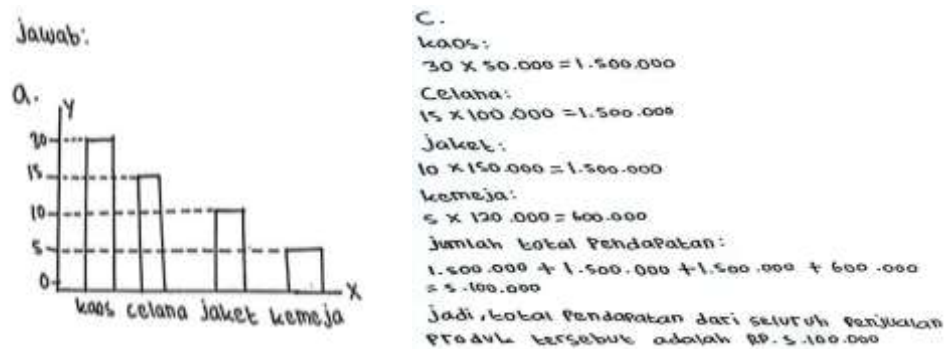


Figure 5. ADF Written Test Results in Relating Mathematical Concepts to Everyday Life

- FTM1 013 : Where do you usually find it?
- ADFM1 014 : just like at the market
- FTM1 037 : Is this kind of question related to everyday life?
- ADFM1 038 : Yes, it is.
- FTM1 039 : What kind of example are you talking about?
- ADFM1 040 : Just like when we sell items, we can calculate our total revenue from our sales.

Based on the written test and interview results, subject ADF was able to relate statistical concepts, particularly bar chart data presentation, to everyday life by identifying sales activities and calculating total revenue. Thus, ADF meets the indicator of relating mathematical concepts to daily life.

Analysis of Data on Students with Average Ability (ADF) in Relating Mathematical Concepts to Other Fields.

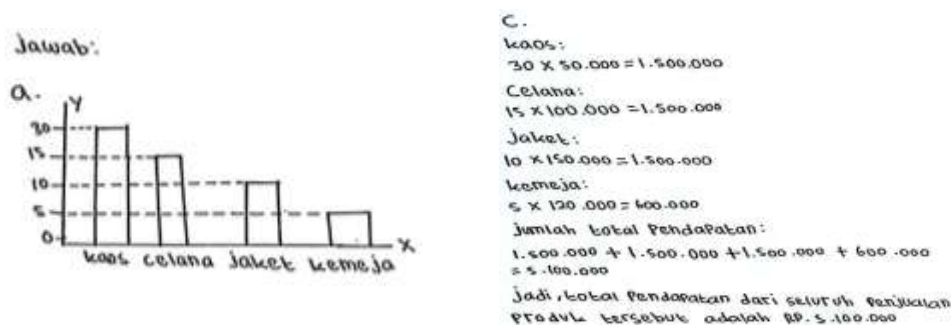


Figure 6. ADF Written Test Results in Relating Mathematical Concepts to Other Fields.

- FTM1 015 : For the example you mentioned, could you explain what field it relates to?
- ADFM1 016 : It is related to economics, for example to identify the best-selling products and those that are less preferred.
- FTM1 035 : What field do questions like this usually related to?
- ADFM1 036 : and the economics field as well, to determine the total profit

Based on the written test and interview results, ADF demonstrated the ability to apply statistical concepts, particularly bar chart data presentation, in the field of economics to represent sales data and identify best- and least-selling products. ADF was also able to calculate total profit using appropriate arithmetic operations. Thus, ADF sufficiently meets the indicator of applying mathematical concepts in other fields.

Analysis of Data on Students with Low Ability (ABD) in Relating One Mathematical Concept to Another

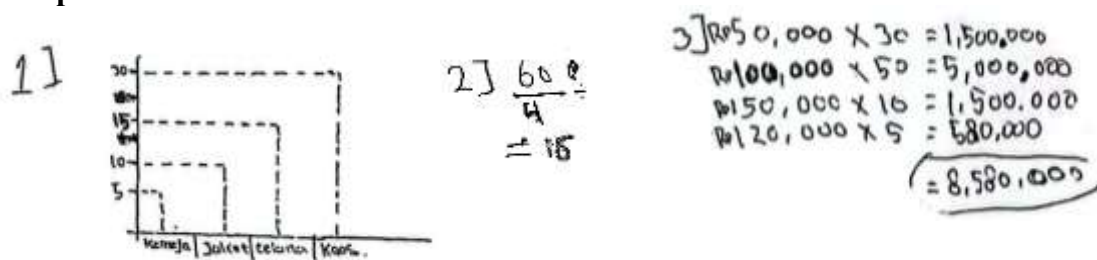


Figure 7. ABD Written Test Results in Relating Mathematical Concepts to Other Fields

- FTM1 011 : How would you solve this problem?
- ABDM1 012 : I drew vertical and horizontal lines, then I filled in the types of clothes for sale and the number of items sold. After that, I forgot how to draw a bar chart, so I just made it like this
- FTM1 019 : Next, how do you solve it?

- ABDM1 020 : First, I add up all the clothing sales, then I divide that total by the number of products. The result is 60 divided by 4, which equals 16.
- FTM1 027 : Next, how do you solving this?
- ABDM1 028 : I multiplied the price by the number of items sold, then added up the total, and the result was Rp 8,580,000.

Based on the written test and interview results, subject ABD showed limited ability to relate statistical concepts to geometric concepts in bar chart representation, with only a basic understanding of axes. ABD also demonstrated incomplete connections between statistical concepts and arithmetic operations, particularly in determining the mean and calculating total revenue, and experienced difficulties with large-number calculations. Thus, ABD performs poorly in meeting the indicator of relating one mathematical concept to another.

Analysis of Data on Students with Low Academic Ability (ABD) in Relating Mathematical Concepts to Everyday Life.

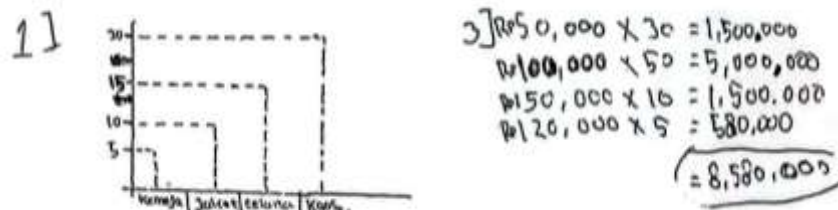


Figure 8. ABD Written Test Results in Relating Mathematical Concepts to Everyday Life.

- FTM1 011 : How do you solve this problem?
- ABDM1 012 : I drew vertical and horizontal lines, then listed the items for sale and the number of items sold. After that, I forgot how to draw a bar chart, so I just made it like this.
- FTM1 013 : So, does a question like this relate to everyday life?
- ABDM1 014 : I'm not really sure about that in everyday life.
- FTM1 033 : Next, what subject does Question C related to?
- ABDM1 034 : "I don't really know.

Based on the written test and interview results, subject ABD showed limited ability to relate statistical concepts, particularly bar chart data presentation, to everyday life. ABD was initially unable to provide relevant examples and required guidance to do so. Thus, ABD performs poorly in meeting the indicator of relating mathematical concepts to daily life.

Analysis of Data on Students with Low Proficiency (ABD) in Relating Mathematical Concepts to Other Fields.

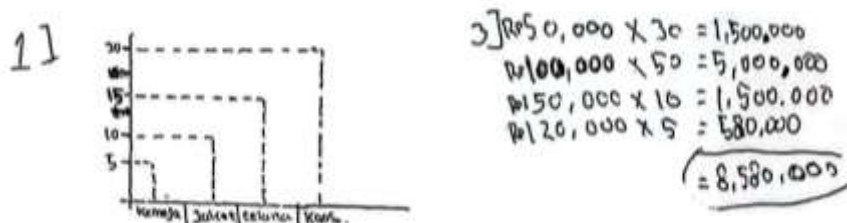


Figure 9. ABD Written Test Results in Relating Mathematical Concepts to Other Fields.

- FTM1 015 : What kind of field do questions like this usually related to?
 ABDM1 016 : I don't know.
 FTM1 033 : Next, what subject does Question C related to?
 ABDM1 034 : "I don't really know."

Based on the written test and interview results, subject ABD showed limited ability to apply statistical concepts, particularly bar chart data presentation, in the field of economics. ABD was unable to explain the connection between mathematics and economics and had difficulty identifying and solving problems related to total revenue. Thus, ABD performs poorly in meeting the indicator of applying mathematical concepts in other fields..

3.2. Discussion

This study reveals clear differences in mathematical connection abilities among students with high, medium, and low levels of mathematical ability when solving statistics word problems. These differences are not only reflected in the correctness of answers, but more importantly in how students construct and integrate mathematical concepts during the problem-solving process.

The Ability of High-Achieving Students (NA) to Make Mathematical Connections When Solving Statistical Word Problems

The first indicator concerns the ability to connect one mathematical concept to another. Students with strong mathematical ability are able to link statistical concepts, particularly data presentation using bar charts, with geometric concepts. In this context, geometric concepts such as rectangles are used to represent each bar, while horizontal and vertical lines function as coordinate axes. In addition, the concepts of scale and proportional length are applied to determine the appropriate height of each bar based on the data values. Therefore, an understanding of geometric principles supports both the accurate construction of bar charts and the effective visual interpretation of data.

Subject NA demonstrated the ability to connect multiple mathematical concepts when solving the given problems. In constructing a bar chart, NA correctly represented data values (30, 15, 10, and 5) on the Y-axis and positioned product categories on the X-axis using geometric concepts such as axes, scale, and proportional length. NA also demonstrated an understanding of the mean by summing the data and dividing by the number of categories, indicating the integration of addition and division within a single problem-solving process. Furthermore, NA applied multiplication and addition to determine total revenue, showing the ability to link arithmetic operations with statistical contexts. These findings indicate that NA possesses strong mathematical connection skills, consistent with previous studies emphasizing the importance of linking concepts in problem solving (Wahid et al., 2024; Radiusman, 2020).

In relation to the second indicator, NA was able to connect mathematical concepts to everyday life by applying statistical representations to real-world contexts, such as identifying best-selling products and calculating total revenue in market situations. This supports the view that students with strong connection abilities can meaningfully apply mathematics in daily life contexts (Mone et al., 2022; Talidobel et al., 2023).

Regarding the third indicator, NA demonstrated the ability to apply mathematical concepts to other fields, particularly economics. NA used bar charts to represent sales data, calculated averages, and determined total revenue, showing an understanding of how mathematical concepts operate within economic contexts. This aligns with the perspective that mathematics is inherently interconnected with other disciplines (Bahar et al., 2023). Thus, ST fulfills all indicators of mathematical connection ability.

The Ability of Students with Average Mathematical Ability (ADF) to Solve Statistical Word Problems

The first indicator of mathematical connection involves linking one mathematical concept to another. Subject ADF demonstrated the ability to connect statistical concepts, particularly bar chart data presentation, with geometric concepts such as axes, scale, and proportional representation. ADF was able to accurately represent sales data using a bar chart and apply arithmetic operations, including addition and division, to determine the mean, as well as multiplication and addition to calculate total revenue. This finding is consistent with previous studies indicating that mathematical connection skills contribute to effective problem solving (Berlinda et al., 2023; Elanda et al., 2024).

Regarding the second indicator, ADF was able to relate mathematical concepts to everyday life by applying statistical concepts in real-life contexts, such as calculating total revenue from sales activities. ADF provided relevant examples and demonstrated an understanding of how mathematical concepts are used in daily situations, supporting the view that mathematics has practical applications in everyday life (Kenedi et al., 2018).

For the third indicator, ADF demonstrated the ability to apply mathematical concepts to other fields, particularly economics. ADF explained that bar charts can be used to identify best-selling and less popular products and that calculating total revenue is relevant to economic activities. This aligns with studies emphasizing the role of mathematical connections in linking mathematics to other disciplines (Syahputri & Hidayati, 2022; Halawati & Hidayati, 2023). Based on these findings, ADF meets all three indicators of mathematical connection ability in solving statistics problems.

The Ability of Low-Achieving Students (ABD) to Make Mathematical Connections When Solving Statistical Word Problems

The first indicator of mathematical connection involves linking one mathematical concept to another. Subject ABD showed limited ability to connect statistical concepts, particularly bar chart data presentation, with geometric concepts. Although ABD could identify vertical and horizontal axes, they were unable to relate these to geometric representations of bar charts. ABD also demonstrated partial understanding in linking statistical concepts with arithmetic operations, such as calculating the mean and total revenue; however, difficulties in division and multiplication with large numbers indicate an incomplete understanding of these relationships.

Regarding the second indicator, ABD showed limited ability to relate mathematical concepts to everyday life. ABD was initially unable to provide relevant real-life examples and required guidance to do so, suggesting that these connections have not yet developed spontaneously.

For the third indicator, ABD was unable to link mathematical concepts to other fields, particularly economics. When asked about the relationship between bar charts, total revenue, and economics, ABD was unable to provide an explanation, indicating a lack of awareness of the interdisciplinary application of mathematics.

Based on these findings, ABD does not meet the three indicators of mathematical connection ability in solving statistics problems. This result is consistent with previous studies indicating that low mathematical connection ability is associated with insufficient prerequisite knowledge (Fadilah et al., 2021).

CONCLUSION

This study concludes that students' mathematical connection abilities differ qualitatively across levels of mathematical ability. High-ability students demonstrate integrated and flexible connections across mathematical concepts, real-life contexts, and

other fields. Medium-ability students are able to form connections, but these remain largely procedural and lack conceptual depth. Meanwhile, low-ability students show fragmented understanding and have difficulty constructing meaningful connections without guidance.

These findings indicate that mathematical connection ability is not merely determined by the ability to perform procedures, but by the depth of conceptual understanding that enables students to relate and integrate various mathematical ideas.

Therefore, mathematics instruction should emphasize the development of conceptual connections by engaging students in tasks that require linking concepts, representations, and real-world contexts. Such an approach is particularly important to support students with medium and low mathematical ability in developing more meaningful and connected understanding of mathematics. However, this study involved a limited number of participants, which may restrict the generalizability of the findings. Future studies are recommended to investigate mathematical connection abilities in other mathematical topics or through intervention-based instructional models.

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