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Implementing Sets to Solve Economic Example Cases Through Mathematical Approach

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A R T I C L E I N F O

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A B S T R A C T

The ability of students to solve mathematical problems is the focus of this study work, which investigates the relationship between students' grasp of high-level mathematics and their ability to do so. The purpose of this study is to investigate the difficulties that students experience when attempting to learn and apply mathematical concepts, specifically in the context of set operations. The ability to solve problems was evaluated by observing and testing a representative subset of the student population. The findings call attention to the significance of fostering mathematical proficiency in students and point to the necessity of establishing instructional methods that strengthen students' ability to solve problems.

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INTRODUCTION

The words "oikos" and "nomos" in Greek are the origin of the English words "economy" and "economics." "Oikos" and "Nomos" signify home regulations, administration, or rules in general, and "human endeavor" is implied by these words. To put it another way, economics, in its broadest meaning, is the study of how individuals and groups make decisions over how to use limited resources to satisfy their requirements in an effort to become prosperous (Purwadinata & Batilmuruk, 2020). Beginning thousands of years ago, human beings have been engaged in economic activity, which led to the creation of modern economies. Some of the most fundamental ideas in economics are explained using straightforward mathematical representations like positive numbers, integers, or fractions, as well as straightforward mathematical operations like subtracting, multiplying, dividing, and adding. The complexity of the economic activities being carried out is constantly expanding. In this particular scenario, the level of difficulty of a problem will have an effect on the analytical instrument that is employed as the problem solution. A mathematical model is one of the instruments that is thought to be capable of articulating the level of difficulty associated with these situations (Ahmad, 2021).

A manner of thinking or frame of mind about economics and business that involves quantitative analysis is to understand economic mathematics. In order to answer economic problems, the branch of mathematics known as economic mathematics makes use of the relevant calculation concepts and procedures. Economic mathematics is a part of mathematics that analyzes economic problems using economic methodologies and symbols. Pure mathematical concepts, such as sets, are applied when studying economic mathematics. For example. A method or analytical instrument for providing a measure of a relationship between variables, which is subsequently condensed into a mathematical model, economic mathematics can be thought of as supplying that measure. To illustrate a point about economics, consider the following scenario: the price of an item determines how much of that item is available for purchase; all other variables affecting the price of the item are held constant (ceteris paribus). If we assume that this relationship is linear, we can clarify it using the linear model $Qs = a + bP$. In this model, Qs stands for the number of items supplied, an is a constant, b is the parameter coefficient, and P is the price (Marlina & Ruhiat, 2018).

A collection or a cluster of a number of distinct objects is what author Dumairy refers to as a set. The item in question could be a number, a person, an animal, a plant, a country, or something else entirely. When presenting a set, it is written in two different methods, the first of which is the list technique, and the second of which is the rule approach. The list method is a method in which all of the objects that are members of a set are listed, whereas the rule method is a method in which particular qualities of the objects that are members of the set are mentioned. When it comes to the operation of sets, there are various different rules of the game in respect to union, intersection, difference, and complement (Pasaribu, 2020) (Komarudin et al., 2023).

When students are studying economic mathematics, particularly sets, it is extremely important for them to be able to link one unit with other units in an effort to find a solution to a problem. If students are able to tie one unit to another, for example, if students can relate economic principles to mathematics, then it is thought that these students have a deeper comprehension of the material. However, the reality on the ground is that the abilities and level of comprehension of students is still very poor. The lack of proficiency that students have in economic mathematics in sets is the root cause of the challenges that students face while attempting to acquire economic mathematical concepts like sets. Solving mathematical problems that either don't have all the answers or do have all the answers but need improvement can help shed light on these shortcomings (Agustina et al., 2019) (Husna et al., 2020). Students who are studying economic mathematics, particularly sets, run into a variety of challenges for a variety of reasons and in a variety of forms. These challenges include difficulties in comprehending the questions that are being discussed, challenges in transforming questions, challenges in solving questions that are given, and challenges in drawing conclusions from answers (Andriani et al., 2019).

Researchers at Megarezky University's Faculty of Economics and Digital Business, for example, frequently find that students have trouble mastering the mathematical foundations of economics. Students are provided with instruction on the significance of economics mathematics courses because it makes it simpler for them to comprehend content associated with economics, including macroeconomics, microeconomics, financial management, and other topics. The study program includes the topic of sets as one of the discussion courses that pertain to economic mathematics and are given to its students. This is demonstrated by the fact that the practice questions associated with the subject have a low value. As a result of this historical context, the researcher has the intention of applying a mathematical strategy to investigate the use of sets in the process of solving economic case cases.

LITERATURE REVIEW

Mathematical Sets

A collection or group that has a specific number of items is referred to as a set. Members, elements, or elements are the terms used to refer to the things that make up or form a set. This collection of things includes things of many different kinds, such as students majoring in economics, creatures that walk on all fours, certain books, sets of negative integers, and so on. The following is the standard format for the writing or notation of a set (Safitri et al., 2023): A set of three major cities in Makassar = {Pare-Pare, Palopo, Bontosunggu} Pare-Pare, Palopo, Bontosunggu is an element or member of a set of Makassar sets denoted Pare-pare ϵ Makassar, Palopo ϵ Makassar, Bontosunggu ϵ Makassar. As described, each object that collectively forms a set is called an element or elements. A set with no element or elements in it is called an empty set (null set = empty set). if the empty set has only one member, namely the empty number = Makassar. The entire totality of the elements of the set collected into a universal set is called sample space = s. As an example of the case of the empty set; a group of 3 students read an economics book. Then obtained a set (Set) consisting of 3 elements or elements. If we only take one student who reads a book on economics, then there is a set with one element or elements. Meanwhile, if we want to get students who have not read economics books, then we will get a set with no elements or elements from the empty set, namely ∅.

How to Illustrate Mathematical Sets

Generally, sets are denoted by capital letters such as A, B, C, D, E, etc. writing a set is divided in two ways, namely:

1. Register Method. All elements of the set are written between the curly braces. For example, a set (Set) S consisting of the numbers 1, 2, 3...8, can be written as follows (Nufus et al., 2022):

$$S = \{1, 2, 3, 4, 5, 6, 7, 8\}$$

This means that the set S has members consisting of positive integers: 1, 2, 3, 4, 5, 6, 7, 8.

2. Method of Rule. As explained the method of rules is a way to include certain characteristics of the objects that are members of the set, for example as follows (Sri, 2018):

$$C = (x ; 3 < x < 9).$$

Set C consists of the object x, where x is a positive integer greater than 3 but less than nine.

Mathematical Sets Operational Forms

In mathematical sets operational illustration, it needs to address the bigger and constant sets. Which these operations are explained as follow (Assauri, 2013):

1. Combination. A union is two sets, namely set A and set B which consists of elements. The elements in question are at least in one set or both. in notation and combined sign of set A and set B, namely ∪. The details are as follows (Winarsih & Mampouw, 2019):

$$A \cup B \quad = \{ x : x \epsilon A \text{ atau } x \epsilon B\}$$

The combination of two sets A and set B can be seen in the Venn diagram as shown in Figure 1:

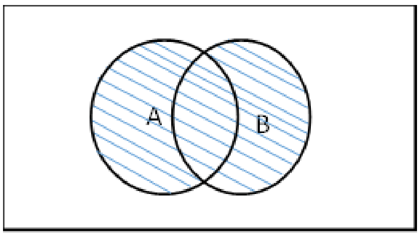

Figure.1 Venn Diagram Showing Combination in Sets A and B

2. Intersection. A slice is a set consisting of elements that are members, both of one set and another set. In both the notation and the intersection sign of the sets A and B is ∩. Thus, the intersection or intersection of sets A and B is stated in the details as follows (Sukirwan et al., 2022):

$$A \cap B = \{x : x \epsilon A \text{ atau } x \epsilon B\}$$

The intersection of two sets A and set B can be seen in the Venn diagram as shown in Figure 2:

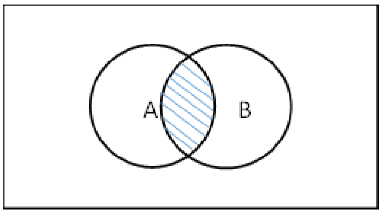

Figure.2 Venn Diagram Showing Intersection in Sets A and B

3. Differences. The difference is two sets whose elements consist of elements of the first set, but which are not elements of the second set. In both notation and sign, the difference between sets A and B is -. so that the difference (difference) of sets A and B is expressed in the following details (Janan et al., 2022):

$$A - B = \{x : \epsilon \text{ A atau } x \notin B\}$$

The difference between the two sets A and set B can be seen in the Venn diagram as shown in Figure 3:

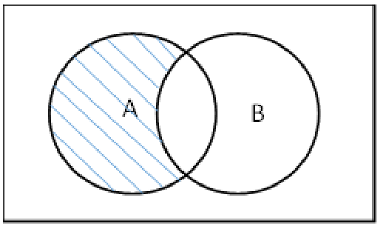

Figure.3 Venn Diagram Showing the Difference in Sets A and B

4. Complementary. Complementary or complement is a set consisting of elements that are also elements of the universal set and is called a sub-set. As for the notation and sign of the complement of set A and set B is Ā. So that the complement of sets A and B is stated in the following details (Aulia & Kartini, 2021):

$$A \text{ atau } A' = \{x \ \epsilon \ U \text{ atau } x \notin B\}$$

The complement of two sets A and set B can be seen in the Venn diagram below:

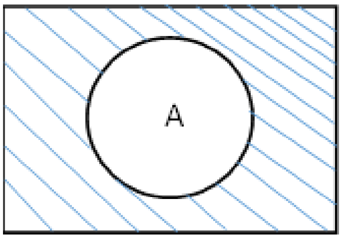

Figure.4 Venn Diagram Showing Complements in Sets A and B

The Contribution of Sets in Mathematic Development in the Context of Economic

Each of these instances has had an impact on science due to the interconnected nature of the functions that sets play in economics, which has developed over the course of many years. An illustration of a situation in which a student's spending on campus necessities is growing to the point that it has an effect on the student's ability to earn more money or revenue.

A change in the value of the variable can be used to indicate a number of different events that take place in the economy. A value is said to be variable if it is subject to change. Some examples of variable values include prices, costs, income, and quantity. Because mathematics is a tool in an analysis, using mathematics allows one to achieve concrete findings in analysis, control tools, and the basis for evaluating. This is one of the reasons why the role of mathematics is so crucial at the present time for analyzing the phenomena of economic events. In order to ensure that the application of mathematical principles will provide outcomes in the form of numbers. In the event that the mathematical analysis produces proper results, but the conclusions still contain empirical mistakes, then the definitions and assumptions need to be followed up on or reexamined in order to gain accuracy and completeness. There are a number of different factors that can be measured in relation to an economic indicator. Because numbers represent quantities, it is theoretically possible to make use of them as a modeling tool in economics provided that the framework that numbers provide is adhered to. For instance, according to the theory of demand, there is a connection between the price of a good and the quantity of that good that consumers want on the market. The term "quantity" refers to the number of individual products, such as books, clothing, food, and so on, that are in high demand on the market. These items exhibit cardinality, which indicates that any number can be superimposed on top of the observed number (Al-Arif, 2013).

METHODOLOGY

This papers employ qualitative methods, which using the approach of study case, this paper are meant to measure the ability of university student to solve mathematical problem, in the context of mathematical sets, which is done by observation, and giving out test and to understand the difficulty the student faces, this paper used interview to obtain answer for future development on the relevant topic. This paper takes six months to complete or a semester, with the intention to fully see the changes in student ability throughout the semester. The total number of students involved is five, which is the student of Megarezky university.

The test is used to assess a subject's level of mathematical connection ability as well as the types of challenges they encountered when answering test questions. While face-to-face questions and answers between the researcher and the subject being examined are utilized in interviews to gather information. Unstructured, open-ended, and very flexible inquiries may be used. It may also change in response to circumstances, such as the use of sets in the mathematical solution of economic problems. In the first part of this study, the researcher will gather data in the form of student exam results from the Faculty of Economics and Digital Business' first semester. Particularly the grades for the prescribed material. The next stage is to decide the time and location of the study, when all subjects are collected in one class to work on the test questions. The researcher will also arrange test questions—up to two questions—and interview rules. The subject's responses will be examined after the test questions have been answered. Interviews are the next method, which serves as confirmation of the test results, allowing for a mathematical analysis of the data collected from the subject and the use of the sets in solving examples of economic issues. The interview process's questions will subsequently be recorded and statedly documented.

RESEARCH RESULT

This paper used a written test to achieve its purpose, which was to measure the capability of students to understand the mathematical topic known as mathematical sets. Additionally, this paper used an interview section to understand what the students lacked in the context of the mathematical topic known as mathematical sets. The sample size for this test is five, and because the number of students in the class that follows this one also remains the same, these five students have been divided into three groups according to their levels of mathematical comprehension: (1) high level of understanding in mathematical topic and material; (2) moderate level of understanding in mathematical topic and material; and (3) low level of mathematical comprehension in mathematical topic and material. These groups are detailed in the table that follows:

Table 1. Level of Understanding Category

Category	Total	Percentage
High level of understanding	1	20
Moderate level of understanding	2	40
Low level of understanding	2	40
Total	**5**	**100**

Sources: Primary Data (2023)

The researcher found that there was one student with a high level of mathematical understanding, with a percentage of 2 percent; two students with a medium level of mathematical understanding, with a percentage of 4 percent; and two students with a low level of understanding, with a percentage of 4 percent. These findings were based on the results of the processing of the data. The researcher will offer written instances to the students based on the processed data in order to establish the level of ability possessed by each individual student (Rahmayani & Effendi, 2019). First of all, the situation is as follows:

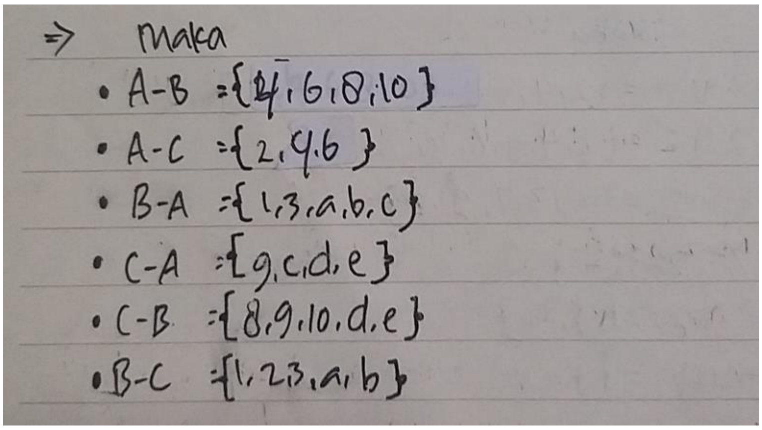

Image.1 First Test Result

It can be seen that the ability to understand high-level mathematics consisting of one student is able to solve the problem cases given properly and correctly, so from the results of these observations, it can be concluded that students do not have any difficulty in solving the problem cases given above, apart from the preparation of the questions from the sm, of course. Based on the test results given by the researcher for the problem cases that explain the set operations consisting of slices, it can be seen that the ability to understand high-level mathematics consisting of few factors, the success of students with high mathematical connection abilities is caused by their capacity to understand concepts, apply principles, and solve verbal problems. As a result, these students do not encounter the challenges that are described in the previous sentence. The findings of this test are in agreement with this research (Sholekah et al., 2017).

The findings of the researchers' interviews with students who are capable of comprehending high-level mathematics revealed that students understood the questions presented by the lecturer; consequently, these students chose to pay close attention to the explanations given by the lecturer. The researchers drew their conclusions from the findings of these interviews. If students are having trouble following the issues that are being presented, they will most likely ask the lecturer who is responsible for that topic directly for clarification. An additional test result is displayed down below.

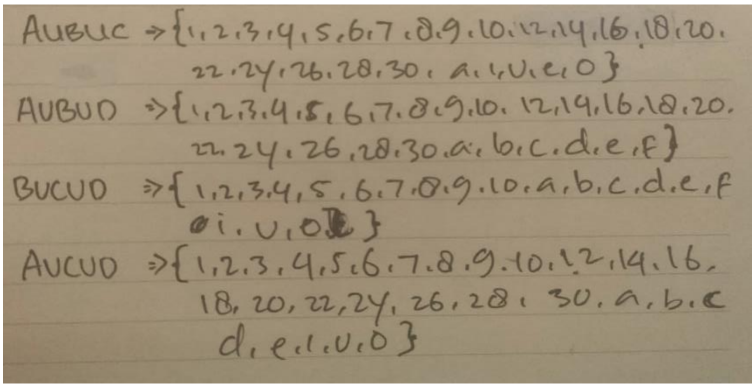

Image.2 Second Test Result

Students with mathematical understanding abilities at an intermediate level are able to write down and match the members of the set from the set operations. More specifically, these students are able to write down and match the combination of members A, B, C, and D. The results of the tests that were given by the researchers show this to be the case. The students arrive at the conclusion that the elements that comprise the set A U C U D are the numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, a, b, c, d, e, I o, u. The researcher then came to the conclusion that there was a mistake in the solution to the case because the pupils neglected to remember the value "f," which was contained within the member of set D.

According to the findings of interviews conducted with students of the Faculty of Economics and Digital Business, the researcher discovered that students did not understand the case because students believed the lesson was difficult to understand. In addition, the researcher discovered that students' lack of attention when the lecturer explained and students' lack of motivation with the subject matter were among the factors that influenced the application of sets in completing an example of an economic case using a mathematical approach is a problem. According to empirical finding, there was a lack of attention, which caused the participants to experience confusion while working on the questions. Despite the fact that they used the appropriate set application, the results that were given were still inaccurate. And as a final point of discussion (Hidayati et al., 2022), a result that suggests a low level of comprehension can be shown below.

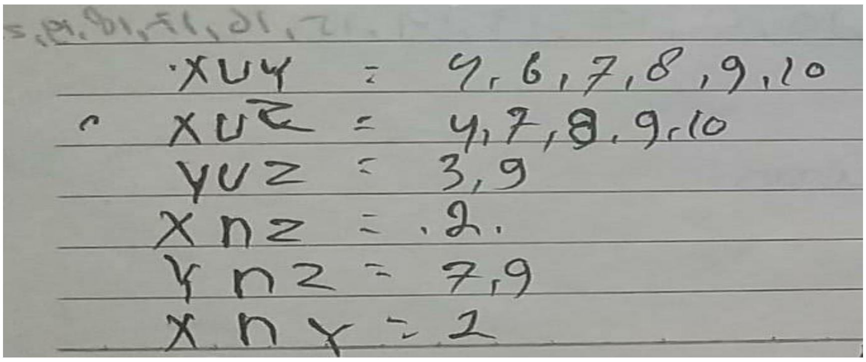

Image 3. Third Test Result

It can be seen that the ability to understand low-level mathematics is not able to solve the problem cases given properly and correctly, so from the results of these observations, students provide answers that are not quite right. This can be seen based on the test results given by the researcher for the problem cases that explain about set operations consisting of unions and intersections.

According to the findings of interviews with students, even those pupils who are capable of comprehending mathematics at a lower level have trouble understanding the problems that are based on the application of the set operations that are taught. This issue can be recognized when looking at the blunders that confused pupils make when trying to solve the challenge of writing the required material. The lack of motivation and talent among students is one of the roadblocks that prevents them from finding solutions to problems. in order to prevent students from adequately grasping what is being conveyed. The following are the factors that prevent people from having the ability to make mathematical connections: (1) inability to comprehend the newly acquired ideas and principles; (2) Not making connections between the new ideas and those that you already have an understanding of; (3) Quickly forget concepts that are poorly understood; (4) The practice of learning through the analysis of examples and questions is not the same as learning through the comprehension of concepts; (5) Consider the material world to be a distinct scientific domain between each of the other ideas; (6) fewer students are aware of the benefits that mathematical principles can provide to support and develop talents in other scientific domains; and (7) The scope of comprehension is restricted to ideas associated with typical life situations (Aliyah et al., 2019).

DISCUSSION

Many empirical evidences have already identified three types of students in terms of solving mathematical problems, especially in terms of mathematical sets, and these evidences explain that ttudents may have difficulty solving mathematical problems for various reasons, which this paper attempts to shed light on. To begin, kids could have trouble grasping the fundamental concepts at play. This may be the result of a failure to understand key mathematical concepts or an inability to recall relevant details. Students may also struggle to put into practice the knowledge and abilities necessary to find a solution. They may have trouble choosing effective problem-solving strategies or converting the provided story problem into mathematical calculations. Students may also incorrectly interpret symbols or values, apply improper procedures, or make other errors in their work. Because of these obstacles and mistakes, their mathematical problem-solving accuracy may suffer (Dwidarti et al., 2019).

To determine if a student has low ability to solve mathematical problems, several indicators can be considered. These indicators are supported by research findings and can be cited as follows (Hidayat & Pujiastuti, 2019):

1. Low achievement in mathematics compared to other subjects: Students with low mathematical skills tend to perform worse in mathematics than in other courses, according to studies.
2. Difficulty in understanding and applying mathematical concepts: Students with low ability may find it difficult to grasp and use mathematical concepts, especially when presented with difficult problem sets.
3. Making frequent errors in problem-solving: When attempting to answer mathematical problems, students with little ability generally make a large number of mistakes. Mathematical blunders, misunderstandings of problem formulations, and improper use of problem-solving methodologies all fall within this category.
4. Inability to develop and execute a problem-solving plan: Students with limited ability may find it difficult to formulate a methodical approach to resolving mathematical difficulties. They may have trouble laying out a plan of action for fixing a problem, which can lead to misunderstanding and mistakes.

5. Lack of attention to detail and carelessness: Poor mathematicians sometimes show sloppiness in their work, whether it is through careless calculations, omitted details, or unchecked solutions.
6. Difficulty in comprehending word problems: Students who are not very strong in mathematics may struggle when faced with word problems. It could be difficult for them to grasp the big picture, define the problem in mathematical terms, and use effective methods to solve it.

These indicators can help educators and researchers identify students with low ability in solving mathematical problems, allowing for targeted interventions and support to improve their mathematical skills. Overall, the difficulties in solving mathematical problems can stem from a lack of conceptual understanding, challenges in applying principles and skills, and errors in calculations or problem-solving strategies.

On the other hand there are few things that indicate students can solve mathematical problem, which is (1) Understanding mathematical concepts and procedures; (2) Applying mathematical knowledge to solve problems; (3) Analyzing and interpreting mathematical information; (4) Formulating strategies and plans to solve problems; (5) Making connections between different mathematical concepts; (6) Communicating mathematical ideas effectively; (7) Demonstrating logical reasoning and critical thinking skills; (8) Persisting in problem-solving tasks and showing perseverance; (9) Reflecting on problem-solving processes and making improvements; (10) Transferring mathematical knowledge to real-life situations (Al Addawiyah & Basuki, 2022).

To enhance students' ability to solve mathematical problems, several strategies can be implemented which expected to improve ability for low level of understanding to moderate level of understanding, especially in term of mathematical problem (Djawa et al., 2022):

1. Reviewing basic mathematical concepts: By revisiting and reinforcing fundamental mathematical concepts, students can improve their problem-solving skills. It suggested that students' prior knowledge and understanding of previous material significantly influence their critical thinking abilities in solving mathematical problems. Emphasizing the importance of emphasizing basic mathematical concepts in teaching.
2. Designing instructional materials: Developing innovative teaching methods and materials can promote critical thinking skills in students. Creating engaging and interactive learning experiences through various instructional tools and techniques can enhance students' problem-solving abilities.
3. Providing story-based problems: Presenting mathematical problems in the form of stories or real-life scenarios can train students to think critically. It also stated that providing story-based problems can help students develop critical thinking skills that are applicable to everyday life situations. It's also suggested that familiarizing students with understanding and solving various mathematical topics can improve their critical thinking abilities.

Overall, instructors can improve students' capacity to solve mathematical problems and develop critical thinking abilities by reviewing basic concepts, devising effective instructional materials, and introducing story-based challenges.

This paper find the result that stated only one student can solve high level mathematical problem, which require few aspect, aligning with empirical research some of this indicator are stated as (1) Understanding the problem: The student is able to correctly identify the known and unknown elements in the problem; (2) Planning the solution: The student is able to connect their existing knowledge to determine strategies or steps that will facilitate problem-solving; (3) Implementing the plan: The student is able to carry out the planned solution by performing calculations or following the steps determined in the previous stage; (4) Checking the solution: The student is able to draw conclusions from their answer and articulate it accurately (Anggraeni & Kadarisma, 2020).

To build student competence in solving high-level mathematical problems, several strategies can be implemented (Adhyan & Sutirna, 2022):

1. Implement problem-based learning: PBL, or problem-based learning, is a method to teaching that encourages the utilization of authentic issues and obstacles. Students' critical thinking and ability to solve problems are bolstered by the approach taken here.
2. Provide scaffolding and guidance: Scaffolding is the process of helping pupils work through difficult difficulties by providing them with structure and direction. Teachers can aid students through difficult activities by providing step-by-step direction, modeling problem-solving skills, and providing prompts or clues.
3. Encourage collaborative learning: Students in a collaborative learning environment work together on projects. This method encourages peers to talk to one another and share their thoughts and experiences. Students in a collaborative learning setting are better able to learn from one another, hone their problem-solving abilities, and broaden their understanding of potential solutions.
4. Emphasize metacognitive skills: Metacognition is the ability to reflect on and analyze one's own cognitive functioning. Metacognitive skills, such as the ability to organize, monitor, and assess one's own problem-solving processes, can be taught directly by teachers. Students can improve as problem solvers and as thinkers by honing their metacognitive skills via practice and reflection.
5. Provide opportunities for open-ended and non-routine problems: Students are challenged to use their imaginations, try new approaches, and consider alternatives when confronted with open-ended and non-routine challenges. Teachers can use these issues to push their pupils to think critically and improve their problem-solving skills.
6. Use technology and manipulatives: Students' participation and retention in problem-solving exercises can be greatly boosted by the use of technological tools and manipulatives. Students' ability to explore concepts and solve problems is enhanced by the visual representations and simulations made possible by virtual manipulatives, graphing calculators, and interactive software.

Teachers are able to assist students in developing their ability to solve complex mathematical problems and build a deeper understanding of mathematical concepts and procedures when they put these tactics into practice in the classroom.

CONCLUSION AND RECOMMENDATION

The results of this study show that students' mastery of advanced mathematical concepts is directly related to their ability to solve mathematical problems. Those students who have a firm grasp of the fundamentals will be able to follow the lecturer's questions and explanations with ease. On the other hand, set operations can be particularly challenging for pupils with a weaker grasp of mathematics. Their capacity to understand and use mathematical ideas is hampered by issues such a lack of focus, enthusiasm, and innate aptitude. Teachers should adopt practices that improve students' ability to tackle challenging mathematical problems and encourage a more thorough comprehension of mathematical ideas and procedures.

To improve future research on students' ability to solve high-level mathematical problems, the following suggestions can be considered:

1. Increase sample size: A modest number of students participated in this study. Future study should try to include a larger and more diverse sample of students to acquire more representative results.
2. Longitudinal study: A longitudinal research that tracks the same group of students over time can shed light on how they acquire the skills necessary to solve more complex mathematical problems. Scientists would then be able to track performance over time and see what influences boosts or dips in efficiency.
3. Control for confounding variables: In order to assure the reliability of the results, it is essential to account for any confounding factors that may be affecting the students' problem-solving skills. Considerations including a person's level of mathematical background, income, and level of schooling are important.
4. Use a mixed-methods approach: Combining quantitative and qualitative methods can provide a more comprehensive understanding of students' problem-solving abilities. Quantitative data can provide statistical analysis, while qualitative data can offer insights into students' thought processes and strategies.
5. Implement intervention programs: Intervention programs that aim to help students become better at solving mathematical problems could be the subject of future study. The efficacy of programs can be gauged by contrasting the results of students who get targeted interventions with those of students who do not.
6. Explore the role of metacognition: Prospective researchers may find success in exploring how pupils' metacognitive talents affect their problem-solving prowess. Effective teaching methods can be based on research into students' metacognitive processes during problem-solving activities.

It will be possible to gain a deeper and more comprehensive understanding of students' mathematical problem-solving abilities if these ideas are taken into consideration in the study that will be done in the future.

ADVANCED RESEARCH

After performing this research, there are few limitations of this research, which serves the purpose as starting point for the next research in the future:

1. Small sample size: The small sample size of this paper makes it difficult to draw any firm conclusions about its results.
2. Lack of longitudinal design: Unfortunately, this paper did not follow the same pupils over time, which would have shed light on how these abilities evolve.
3. Potential confounding variables: This paper did not account for potential confounding variables, such as pupils' prior exposure to mathematics, family income, or years of formal education.
4. Limited focus on metacognition: The impact of pupils' metacognitive abilities on their ability to solve problems was not thoroughly investigated.
5. Lack of intervention programs: Intervention methods designed to boost pupils' ability to solve mathematical problems were not examined in this paper.

Based on these limitations, future research should focus on the following areas:

1. Increasing sample size: In order to get more accurate results, future research should try to recruit a larger and more varied student body.
2. Conducting longitudinal studies: Understanding how a cohort of students acquires the knowledge and abilities to tackle difficult mathematical problems requires following that cohort through time.
3. Controlling for confounding variables: A person's socioeconomic status, degree of education, and mathematical aptitude should all be taken into account to ensure accuracy.
4. Exploring the role of metacognition: It is important to study how students' metacognitive skills relate to their problem-solving abilities in the classroom.
5. Implementing intervention programs: Mathematical problem-solving intervention programs can be assessed for their effectiveness in future research.

Overall, future research should try to overcome the limitations of the present study by using bigger sample numbers, longitudinal designs, controlling for confounding variables, studying the impact of metacognition, and investigating the efficacy of intervention programs.

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