JOURNAL LA EDUSCI

VOL. 07, ISSUE 01 (249-262), 2026
DOI: 10.37899/journallaedusci.v7i1.2960

Analysis of Challenges and Solutions to Students' Understanding of Mathematical Concepts in Algebra Material from Gender Perspective

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Article Info

Article history:
Received 26 December 2025
Received in revised form 23 January 2026
Accepted 25 February 2026

Keywords:
Algebra
Gender
Conceptual Understanding Of Mathematics
Middle School Students

Abstract

Algebra is one of the crucial topics in mathematics. However, many students struggle to master algebra concepts. If this is left unchecked, it will have a negative impact on the students' future. Students will have difficulty following mathematics lessons at higher levels, because algebra is the foundation of many advanced mathematical concepts. This research aims to conduct a case study on the understanding of mathematical concepts from a gender perspective and a literature review to determine the challenges and solution approaches to the understanding of mathematical concepts among middle school students in algebra. The methods applied are Systematic Literature Review (SLR) and case study research. The research results show that female students' understanding of algebra concepts is very good. Female students can explain examples and algebraic operations well and correctly. However, male students do not master the material well because they often make mistakes in algebraic operations. The main cause of the low understanding of algebra concepts among students is their inability to connect formulas and concepts with practical applications, lack of student engagement in the learning process, insufficient interactive learning media, and inadequate teaching methods. The proposed solutions are the use of more engaging and interactive media, the implementation of active and collaborative learning methods, and the utilization of technology in education.

Introduction

Mathematics is a fundamental science that serves as the foundation of modern knowledge and technology (Onoshakpokaiye & Avwiei, 2025; Li et al., 2025; Nanda & Rani, 2025). In addition, mathematics helps people become proficient in logical reasoning, problem analysis, and abstraction (Tayraukham et al., 2009; Yadav, 2019). Therefore, mathematics plays a role in helping to understand the environment and developing it into technology that is beneficial for human welfare. Problems that arise in the fields of agriculture, industry, economy, and health can be addressed through mathematical approaches (Kuznetsova et al., 2021; Lafuente-Lechuga et al., 2020). Mathematics plays an important role in learning because it contributes to the development of critical thinking skills, problem-solving, and data analysis (Sachdeva & Eggen, 2021; Zakaria & Syamaun, 2017). By understanding basic concepts such as numbers, arithmetic, geometry, operations, and algebra, students can tackle various problems in both academic fields and everyday life (Lafuente-Lechuga et al., 2020; Xu, 2025; Kurudirek et al., 2025). So, mathematics is very important in solving everyday problems. Therefore, mathematics is an essential subject to be taught at all levels of education (Dörfler & McLone, 1986; Teise, 2025; Aliu et al., 2025).

In the Decision of the Head of the Standards, Curriculum, and Assessment Agency of the Ministry of Education, Culture, Research, and Technology (BSKAP Kemendikbudristek)

ISSN 2721-0979 (Print), ISSN 2721-1258 (Online)

Number 032/H/KR/2024, the objectives of mathematics learning are outlined, one of which is: Having an understanding of mathematical concepts and procedural skills, this decision shows a stronger emphasis on understanding mathematical concepts in the Merdeka Curriculum. This decision includes the goal of enhancing essential understanding of various mathematical concepts, such as numbers, algebra, geometry, and probability. It is hoped that this approach can encourage students not only to memorize information but also to understand how these concepts can be applied in everyday life (Hoque, 2019; LeCun et al., 2015).

Understanding mathematical concepts refers to a person's ability to accurately comprehend and grasp the essence of a concept or idea, without altering its original meaning (Yang et al., 2021; Nasrullah et al., 2025; Asda et al., 2025). A basic understanding of mathematical concepts enables students to teach those concepts to others more deeply (Herawati et al., 2024; Mwakapenda, 2004; Jannah et al., 2025). The ability to understand the relationships between various concepts in mathematics is very important According to NCTM in (Haji, 2019), the main goal of learning mathematics is to understand concepts. After students understand the concepts, they will find it easier to solve various mathematical problems.

However, the reality according to the PISA 2022 results is that students' understanding of mathematical concepts in Indonesia is still relatively low. The PISA 2022 results show that only about 18% of students in Indonesia reached at least level 2 (basic proficiency) in mathematics, which is far below the international average of 69%. This is in line with the findings of the Trends in International Mathematics and Science Study (TIMSS) 2019, which stated that Indonesian students still have a poor understanding of mathematical concepts. This study measures the mathematical abilities of students in grade 4 and grade 8 across various countries. The TIMSS 2019 results show that students in Indonesia have achievements below the international average standard in various domains of mathematics, including conceptual understanding. At the 8th-grade level, only about 23% of students in Indonesia reached the High Benchmark in mathematics, compared to the international average of 42%. This proves that students do not have a good understanding of mathematical concepts.

The low understanding of mathematical concepts among students indicates that understanding mathematical concepts is important for students to solve problems in a particular mathematical subject. One important topic for students to understand is algebra. Algebra is a field of mathematics that explains the relationships between various elements using mathematical statements. Based on Booker in (Hodgen et al., 2018), algebra is very useful as a method for solving computational, business, economic, trade, advanced mathematics, and science problems, as well as various other problems in daily life. This makes students reliable problem solvers. Algebraic thinking is a quantitative approach that focuses on general relationships using various tools, not just symbols. These tools can be used as cognitive means to introduce and maintain algebra discourse at the standard class level (Hodgen et al., 2018; Sibgatullin et al., 2022). Students are taught to think critically, creatively, logically, and abstractly through algebra learning.

However, many students say that the topic of algebra is often considered challenging to understand. In (Setianingrum et al., 2020) research, it was shown that students often face challenges in identifying variables and constants, as well as applying the concept of division in algebra. In (Ying et al., 2020) research, it was shown that students often face problems in understanding positive and negative operations, making calculation errors, and using incorrect processes. Furthermore, (Filgona et al., 2020) states that although students have high learning motivation, they still encounter problems in interpreting and understanding algebraic concepts, as well as simplifying algebraic multiplication and division forms. If this condition is not

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addressed, it will certainly have negative consequences for the student's future; the student will struggle to follow mathematics lessons at higher levels, as algebra is the foundation of many advanced mathematical concepts. Additionally, students' grades in exams and tests could decline, which will ultimately affect their opportunities to further their education. Another consequence is that it can limit career choices and reduce job opportunities in the future because many professions in the fields of science, technology, engineering, and mathematics (STEM) require a strong understanding of algebra.

To address the impact, it is important for us to understand the challenges and the approaches to the solutions. Therefore, the researchers consider this study important and will conduct research titled "Analysis of Challenges and Solutions to Students' Understanding of Mathematical Concepts in Algebra Material from a Gender Perspective". The findings from this study are expected to provide valuable insights for educators in developing more effective and inclusive teaching strategies.

Methods

Systematic Literature Review Method

Eligibility Criteria and Data Analysis

This research uses a qualitative research type employing the SRL (Systematic Literature Review) method. The researcher identifies, reviews, evaluates, and interprets all available literature. This method allows researchers to systematically review and identify journals.

To support this research, the researchers collected journal articles from Google Scholar. The selected articles are those published between 2020 and 2024. The following steps are used to conduct a systematic literature review and PRISMA meta-analysis: (1) Determine the topic and search for relevant articles or topics; (2) Filter documents to identify articles that match the topic; (3) Check the credibility of the collected articles; and (4) Review, analyze, synthesize, and describe the collected articles. The selection of articles uses keywords related to the understanding of mathematical concepts, algebra, and their combination.

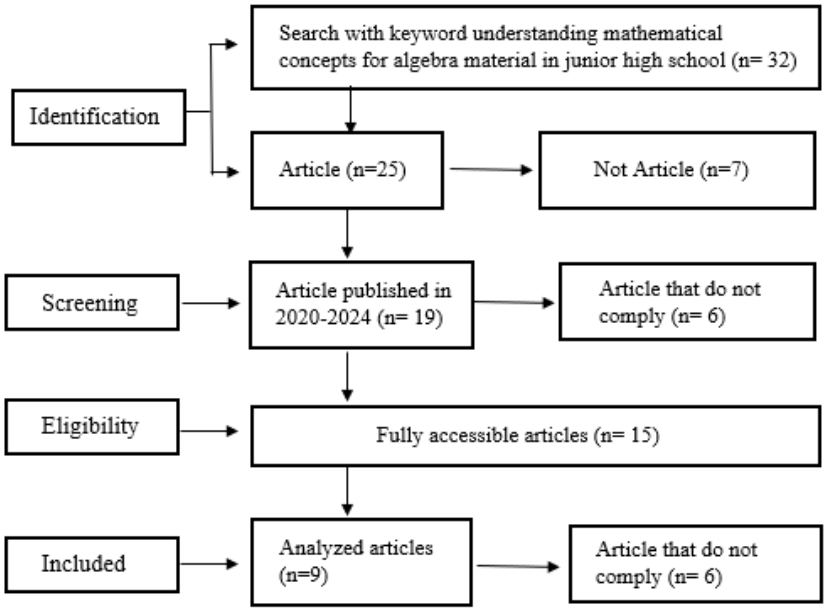

Figure 1. PRISMA Flowchart

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Source of Information

Data were collected based on the content analysis results of all mathematics concept comprehension articles, accessed on Google Scholar on November 5, 2024. The articles were selected based on their relevance to the topic, focusing on studies that discuss gender differences in understanding mathematical concepts, particularly in algebra.

Search Strategy

To search for articles on the understanding of mathematical concepts, the method used is: (1) Go to the Google Scholar website, or open https://scholar.google.com/; (2) Type the keywords: understanding mathematical concepts or algebra; (3) Select the year filter menu; and (4) Choose the article you want to download. After identifying the relevant articles, researchers review the abstracts and full texts to ensure the studies align with the research objectives, focusing specifically on gender perspectives and challenges in understanding algebra concepts.

Case Study Research Method

This research was conducted at SMP Islam Excellent Plus Bukittinggi, located at Jl. Bahar Kamil, No. 5, Ganting, Bukittinggi, West Sumatra in the even semester of the 2024/2025 academic year. The subjects of this research consist of 1 male and 1 female. Both were selected based on their high abilities from each gender. The research instrument consists of the main instrument, which is the researcher themselves, and supporting instruments, namely written task sheets and interview guidelines. The written task sheets presenting algebra problems have been created based on concept comprehension indicators. Data collection was conducted through the provision of written task sheets. Next, time triangulation and member checking are used as tests of data credibility. The data analysis used includes data condensation, data display, and conclusion drawing/verification (Noble & Heale, 2019). The indicators of conceptual understanding used in this research are: (1) restating the concept; (2) using, utilizing, and selecting certain procedures or operations; (3) applying the concept or algorithm. These indicators were chosen because they align with the material being studied.

Results and Discussion

Solutions and Challenges in Understanding Mathematical Concepts in Algebra

The research data included in this literature review is a tabulation of articles documenting the challenges and solution approaches for understanding mathematical concepts in algebra, with a total of 9 articles. For more clarity, see Table 7.

Table 1. Results of the Literature Review Research

Authors	Journal	Research Results
Pramesti & Retnawati (2019)	Journal of Physics: Conference Series	There are three main areas where students make mistakes when preparing algebraic problems: comprehending the problem, comprehending the meaning of variables, and using algebraic expressions. Numerous follow-up studies can be carried out to investigate the challenges that students have when studying algebra. Therefore, in order to reduce the amount of difficulty that students face when studying algebra, teachers might devise ways for teaching the subject.
Hadi, (2023)	Journal Neosantara	The results of this study indicate that the guided discovery learning model (Discovery Learning) is

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	Hybrid Learning Mau'izah: Jurnal Kajian Keislaman	effective in enhancing students' ability to understand mathematical concepts at SMPN 2 Praya Timur.
Siniguian (2017)	International Journal of Advanced Research in Engineering and Applied Sciences	Students have difficulty solving problems because they tend to rely solely on memorizing formulas, but are less able to connect those formulas with various concepts in problem-solving.
Sugiarti & Retnawati, (2019)	Journal of Physics: Conference Series	The research results show that there are difficulties for students in solving algebra problems related to concepts and principles. The difficulties experienced by students related to the concept of difficulty in determining variables and constants include, but are not limited to, a lack of understanding of the definitions of variables and constants, as well as difficulties in applying the concept of division in algebra. The difficulties experienced in terms of principles are the application of the addition principle in algebraic forms, reduction in algebraic forms, multiplication in algebraic forms, simplification of algebraic fractions, factorization, and solving story problems related to algebra.
Son et al. (2020)	Journal on Mathematics Education	Mathematics learning is still teacher-centered. Students experience confusion and difficulty understanding the concepts taught by the teacher, which is caused by miscommunication between the teacher and the students. Additionally, students usually only contribute to one example problem given by the instructor and use memorization techniques that are appropriate for that specific example problem. The solution is to implement the Scaffolding method.
Sari et al., (2019)	International Journal of Educational Dynamics	There are three main areas where students make mistakes when preparing algebraic problems: comprehending the problem, comprehending the meaning of variables, and using algebraic expressions. Numerous follow-up studies can be carried out to investigate the challenges that students have when studying algebra. Therefore, in order to reduce the amount of difficulty that students face when studying algebra, teachers might devise ways for teaching the subject.

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Algani & Eshan, (2019)	International e-Journal of Educational Studies	The low interest of students in mathematics causes difficulties in receiving the material presented only through the lecture method. In addition, the lack of visual aids to help students direct their lessons also becomes a factor. To address this, an algebra board teaching aid (Algebra Board) was developed.
Kholid et al., (2021)	Journal of Physics: Conference Series	Students tend to be passive and only memorize mathematical concepts without understanding their meaning. They only take notes of the explanations, listen to the teacher's material, and solve the assigned problems.
Egodawatte (2009)	Acta Didactica Napocensia	There are three main areas where students make mistakes when preparing algebraic problems: comprehending the problem, comprehending the meaning of variables, and using algebraic expressions. Numerous follow-up studies can be carried out to investigate the challenges that students have when studying algebra. Therefore, in order to reduce the amount of difficulty that students face when studying algebra, teachers might devise ways for teaching the subject.

The main challenge in understanding mathematical concepts, especially in algebra, is the abstraction and symbolism inherent in this topic. As in Sugiarti & Retnawati (2019) research, any students have difficulty understanding the symbols and rules applied in algebra, such as operations with variables and equations. In addition, limitations in basic mathematical understanding such as arithmetic and other fundamental concepts can exacerbate these difficulties. Low motivation and interest in mathematics also become factors that affect students' ability to understand algebra material (Zain & Rahayu, 2023).

The solution to overcoming this challenge involves a more interactive and contextual approach in teaching. Teachers can use visual aids, such as diagrams and graphics, as well as educational technology like math applications and educational games to explain algebra concepts in a more engaging and easily understandable way. Problem-based learning approaches and the use of real-life examples can help students see the relevance of algebra in real-world contexts. Additionally, providing extra support through tutoring and remedial sessions can also help students who are struggling to gradually improve their understanding.

Based on the identification from the table above, it can be concluded that the challenges faced by students in algebra material are as follows:

The concept is difficult to understand.

Many students face problems in understanding basic algebra concepts, especially in identifying elements such as variables, coefficients, and constants. These difficulties are exacerbated by misconceptions, such as misconceptions of generalization, notation, and the application of rules that are not properly understood.

Mistakes in the problem-solving process.

Often, students make conceptual, procedural, and technical errors when solving algebra problems. Technical errors, caused by carelessness, are the most frequently occurring. Students also tend to rely on memorizing formulas without understanding the process.

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Limited learning methods.

Learning that is still conventional, especially with a dominant lecture model and less active student involvement, causes students to feel bored and passive. This hinders a deep understanding of algebraic concepts.

The lack of creativity and the use of engaging learning media.

Learning that tends to be monotonous and does not involve technology or engaging learning media makes students show no interest and have difficulty understanding the material.

Lack of understanding in different mathematical representations. Many students struggle to understand algebra in various representations, such as symbols, word problems, or other algebraic forms.

From those challenges, several solutions have been provided to enhance understanding of mathematical concepts related to algebra, as follows:

The use of interactive and innovative learning media.

The use of more engaging and interactive learning media, such as Interactive PowerPoint, crossword puzzles, algebra boards, algebra puzzles, and ethnomathematics-based games, can help students become more interested and active in learning. This fact shows that students' conceptual understanding can be improved with these methods because the media are more enjoyable and support visual and practical understanding.

A teaching method that encourages active student participation during the learning process.

The scientific approach, Discovery Based Learning, project-based learning (PBL) method, and Scaffolding method can help students understand concepts better through practical experience and discussion. Using cooperative learning models such as STAD (*Student Team Achievement Division*) and TPS (*Think Pair Share*) has been proven to enhance student cooperation and motivation, making them more active and engaged in learning.

Enhancing teachers' creativity in delivering lessons.

Teachers need to be more creative in selecting and designing teaching methods and media that not only enhance students' knowledge but also make learning enjoyable and engaging, for example, by using teaching aids or educational games.

A more in-depth approach to student misconceptions.

Teachers need to better understand and address the misconceptions held by students, such as generalization misconceptions or notation errors. A more systematic delivery of material and the use of relevant examples can help students avoid those conceptual errors.

Understanding Mathematical Concepts of Algebra from a Gender Perspective

To test the understanding of mathematical concepts in algebra, one student of each gender with the highest score in the high ability group was selected. The female student chosen as the research subject is SMA, and the male student chosen as the research subject is AAZF.

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Understanding of Concepts by Female Student (SMA)

SMA's Data Analysis in Restating Concepts

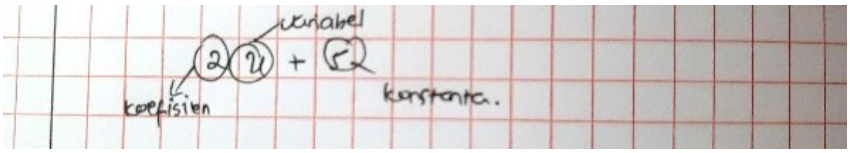

Figure 2. SMA's Answer No.1

Based on Figure 2, SMA restates the concept by grouping coefficients, variables, and constants.

Table 2. Transcript of the SMA No. 1 interview

Author	:	What is being asked in question number 1?
SMA	:	Determine which are the variables, coefficients, and constants.
Author	:	So, which one is the variable, the coefficient, and the constant?
SMA	:	The variable is x, the coefficient is 2, and the constant is 5.
Author	:	What is the difference between a coefficient and a constant?
SMA	:	A coefficient is a number accompanied by a variable, while a constant is a number that stands alone.

Based on Table 2, SMA is able to restate the concept by differentiating between variables, constants, and coefficients.

SMA Data Analysis in Using, Utilizing, and Selecting Specific Procedures or Operations

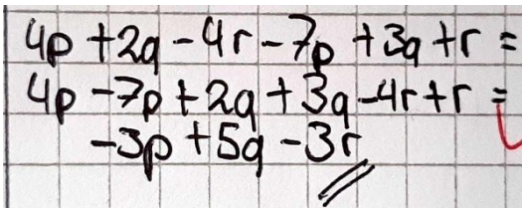

Figure 3. SMA's Answer No.2

Based on image 3, SMA operates algebra by first grouping its subgroups.

Table 3. Transcript of SMA no 2 interview

Author	:	When can we add or subtract algebra?
SMA	:	If the variables are the same
Author	:	So, what should we do first to solve this question number 2?
SMA	:	Grouping numbers that have the same variable

Based on Table 3, SMA is able to use, utilize, and select certain procedures or operations.

SMA Data Analysis in Applying Concepts or Algorithms

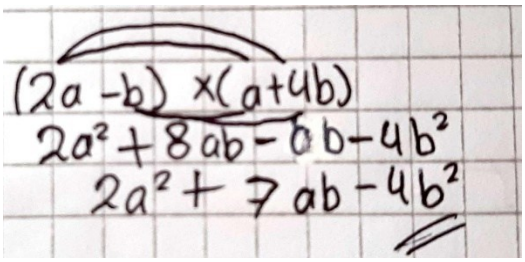

Figure 4. SMA's Answer No.3

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Based on image 4, SMA applies the concept or algorithm by performing the distribution of multiplication, then subtracting the same terms.

Table 4. Transcript of SMA no 3 interview

Author	:	So what should we do to solve this problem?
SMA	:	Let's do the rainbow multiplication first. So we multiply first $2a$ with a we got $2a^2$. Then multiplied $2a$ by $4b$ we got $8ab$. Then $-b$ multiplied a equal $-ab$. Finally, $-b$ multiplied $4b$ and $-4b^2$ obtained. Then, because $2a^2$ have no friends of the same ethnicity, it just gets copied $2a^2$. $8ab$ there is a friend from the same tribe $-ab$ so we got $7ab$, $-4b^2$ have no friend from the same tribe, so just copy it.

Based on Table 4, high school students are able to apply concepts or algorithms.

Understanding the Concept of Male Students (AAZF).

Analysis of AAZF Data in Restating the Concept

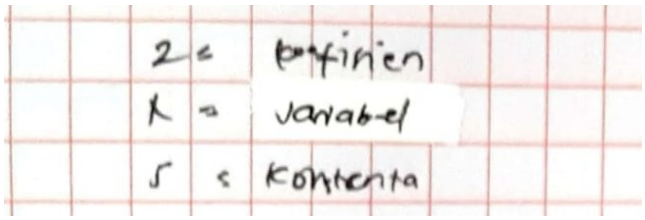

Figure 5. AAZF's answer no 1

Based on Figure 5, AAZF restates the concept by grouping coefficients, variables, and constants.

Table 5. Transcript of interview AAZF no 1

Author	:	Try to explain why you made 2 as coefficients, x as variable, and 5 as constants.
AAZF	:	Because x is a letter, it becomes a variable, 2 is in front of x, so it is the coefficient, and 5 is the constant.
Author	:	So what's the difference between a coefficient and a constant?
AAZF	:	The coefficient is the number in front of the variable. A constant is a single number.

Based on Table 5, AAZF is able to restate the concept by expressing the differences between variables, constants, and coefficients.

Analysis of AAZF Data in Using, Utilizing, and Selecting Specific Procedures or Operations

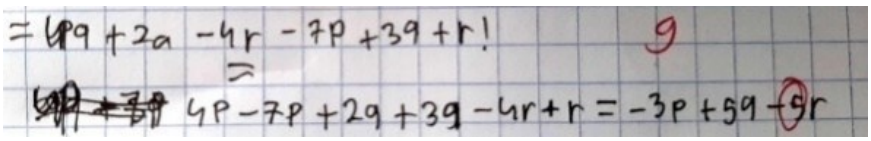

Figure 6. AAZF's answer no 2

Based on Figure 6, AAZF operates algebra by first grouping its tribes.

Table 6. Transcript of interview AAZF no 2

Author	:	What should we do first to solve this problem?
AAZF	:	Equalizing the variables

ISSN 2721-0979 (Print), ISSN 2721-1258 (Online)

Author	:	After that?
AAZF	:	Then subtract $4p - 7p$ equal to $-3p$. $2q + 3q$ equal to $5q$. And $4r + r = 5r$
Author	:	$4r$ or $-4r$?
AAZF	:	Eh, it should be $-4r$
Author	:	If its $-4r$ then whats the suppose answer?
AAZF	:	$-4r + r$ equal $-3r$

Based on table 6, AAZF is able to use, utilize, and select certain procedures or operations, but due to haste and lack of precision, there are minor errors at the end.

AAZF Data Analysis in Applying Concepts or Algorithms

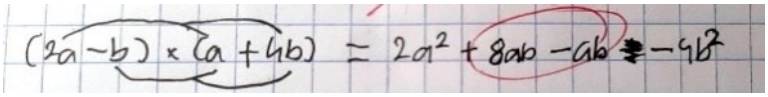

Figure 7. AAZF's answer no 3

Based on image 7, AAZF applies the concept or algorithm by performing the distribution of multiplication, then subtracting the same terms.

Table 7. Transcript of interview AAZF no 3

Author	:	What should we do first to solve this problem?
AAZF	:	Rainbow multiplication
Author	:	How the Rainbow multiplication's work?
AAZF	:	$2a$ times a equal $2a^2$. Then $2a$ times $4b$ equal 8ab. Then $-b$ times a equal $-ab$. Lastly $-b$ times $4b$ equal $-4b^2$.
Author	:	After that? Is it finished there?
AAZF	:	If the difference of variables cannot be summed
Author	:	Are all the variables different?
AAZF	:	Eh, ab are the same.
Author	:	So, what's the final result?
AAZF	:	$2a^2 + 7ab - 4b^2$

Based on table 7, AAZF is able to apply the concept or algorithm but is not meticulous in observing the variables, resulting in errors at the end.

Based on the analysis of the indicator of restating concepts, high school students are able to state and explain which are variables, coefficients, and constants in their own language accurately. On the indicator of using, utilizing, and selecting certain procedures or operations, high school students are able to operate algebra by first grouping the terms, and then performing the operations. And high school students can also explain that algebraic addition and subtraction operations can only be performed when they are like terms, meaning they have the same variable. For the indicator of applying concepts or algorithms, high school students can operate it by first performing the distribution of multiplication, then operating it according to the rules, namely subtraction or addition must be done with the same variable. This is in line with what was stated by McMurran et al., (2023) and Nieto-Isidro & Martínez-Abad (2024) that women excel in accuracy, precision, and meticulousness in solving problems.

On the indicator of restating concepts, AAZF can express the differences between variables, coefficients, and constants in their own language. On the indicator of using, utilizing, and selecting certain procedures or operations, AAZF is able to operate algebra by grouping terms, but there is an addition error at the end due to lack of precision. On the indicator of applying concepts or algorithms, AAZF can perform multiplication by first distributing the

ISSN 2721-0979 (Print), ISSN 2721-1258 (Online)

multiplication, however, AAZF did not perform the subsequent subtraction because they did not notice that there were like terms. This is because AAZF was in a hurry while solving the problem. As stated by McMurran et al., (2023) and Nieto-Isidro & Martínez-Abad (2024), men are less meticulous and tend to rush when solving problems. This is also evident from AAZF's work, which is untidy and has scribbles, indicating that AAZF was in a hurry while solving the problems.

Conclusion

From the results and discussion presented above, it can be concluded that from a gender perspective, female students (SMA) can restate concepts, use, utilize, and select certain procedures or operations, as well as apply concepts or algorithms neatly and meticulously. Meanwhile, male students (AAZF) restate concepts, use, utilize, and choose certain procedures or operations, as well as apply concepts or algorithms hastily, resulting in errors.

The main cause of the low understanding of algebra concepts among students is their inability to connect formulas and concepts with practical applications, lack of student engagement in the learning process, insufficient interactive learning media, and inadequate teaching methods. The proposed solutions are the use of more engaging and interactive media, the implementation of active and collaborative learning methods, and the utilization of technology in education. This research is only focused on mathematics lessons with algebra material. Therefore, it is hoped that research will also be conducted on a broader range of mathematical topics.

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