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The Structure Of Algebraic Argumentation Of High School Students With The Toulmin Model

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***Abstract**: Mathematical argumentation is an important skill that must be owned in the 21st century. The purpose of the research is to analyze the structure of high school students' algebraic argumentation using the Toulmin model which consists of claim, data, warrant, and backing. This study involved 35 students in the odd semester of the 2022/2023 academic year at Muhammadiyah 1 Palembang High School. The students were asked to provide algebraic argumentation in mathematical proofs related to the quadratic function theorem. The algebraic argumentation was then analyzed using the Toulmin model. The results showed that 14.28% of students' mathematical argumentation skills were at level 5; 62.86% of students' mathematical argumentation skills were at level 4; 20% of students' mathematical argumentation skills were at level 3; 2.86% of students' mathematical argumentation skills were at level 2; and no students were at level 1.*

Keyword: 21st Century, Algebra, Mathematical Proofs, Quadratic Function, Toulmin Model.

INTRODUCTION

Education in the 21st century requires students to think critically, communicate opinions, collaborate and think creatively in learning activities (Sugiyarti et al., 2018). Argumentation skills are one of the 21st century skills that need to be possessed by learners because they involve informal reasoning abilities and involve problem solving, making statements, making decisions supported by data and evidence and forming ideas (Bahri et al., 2021). Argumentation ability is the ability of individuals to provide answers and reasons for available problems and evidence in the form of appropriate data and theories (Thariq et al., 2023). As stated by Zulainy et al. (2021) that argumentation skills are the ability of students to draw conclusions based on existing facts or information.. Argumentation by Ruggiero (2014) is defined as a statement that is supported by evidence so that it can influence the minds of others.

However, the reality is that students' argumentation skills are still low. This is in line with the research results (Resmi et al., 2021) who found that only 20% of students have argumentation skills. Then the results of research by Indrawatinignsih et al. (2020) that 69% of students tend to make errors related to procedural and conceptual understanding of mathematical argumentation. In line with what Syerlina said (2018) that the average score of students' argumentation is still below 50%. Students can express their opinions but have not been able to provide reasons and evidence to support their opinions (Agustiningsih et al., 2021).

The cause of students' low argumentation skills is because students are not accustomed to practicing their scientific argumentation skills and also because their concept mastery skills are still lacking. (Wulandari et al., 2023). According to Annisa and Wibowo (2022) the cause of students' low argumentation skills because it is influenced by the factor of students' lack of understanding of the topic discussed. The low level of

argumentation skills is also influenced by the steps of the learning process that have not maximized students to argue (Rahmadhani et al., 2020).

So that teaching materials are needed that can help students understand concepts while supporting argumentation skills, namely teaching materials with a proof approach. Proving is one of the main characteristics of mathematics as a discipline (Rabin & Quarfoot, 2021) and is the foundation of mathematics (Hanna, 2018). Argumentation and proof are important parts of mathematics that are interconnected (Laamena, 2017). In line with the statement of Faizah et al. (2021) who said that an argument is a proof that contains rational justification to get a conclusion. Proofs and arguments are two important things in mathematics where they are interconnected (Siahaan et al., 2021).

The quality of students' argumentation in preparing mathematical proofs can be analyzed using Toulmin's argumentation model (Sholihah et al., 2021). This model, known as Toulmin's Argument Pattern (TAP), describes a framework for providing an argument consisting of claim, evidence, warrant, backing, qualifier and rebuttal (Meylani, 2018). A person's mathematical argumentation can be measured through questions that support students to provide claims, data and warrants (Pramesti & Rosyidi, 2020). The advantages of using Toulmin's argumentation model in proof are seen in its ability to formulate structured and clear arguments (Arifin et al., 2023).

One of the appropriate materials to train students' argumentation skills is the quadratic function which is included in the algebra category. Algebra is a branch of mathematics that requires logical thinking because algebra contains mathematical statements that need to be proven true (Faizah et al., 2021). Quadratic function is a material that requires solving with a fairly high level of accuracy because there are several ways in the process of solving it (Situmorang, 2021). In quadratic functions, the learner has difficulty recalling the formulas he has learned (Azmi & Yunita, 2022).

Some studies that examine proof using the toulmin model are research from Thariq et al. (2023) who analyzed argumentation skills on numeracy questions. Then research from Pramesti and Rosyidi (2020) who conducted research on students' argumentation profiles in solving PISA-type problems. Then the research conducted by Sholihah et al. (2021) who conducted research on argumentation skills on triangle congruence material. But researchers have not found research on argumentation skills on quadratic function material using the Toulmin model. Based on this description, researchers are interested in conducting research that aims to analyze the algebraic argumentation skills of high school students using the Toulmin model.

METHOD

The research conducted by researchers is descriptive qualitative research. Qualitative descriptive research is research that describes existing phenomena and displays data without the manipulation process (Rusandi & Muhammad Rusli, 2021). This research was conducted at Muhammadiyah 1 Palembang high school. The subjects in this study were 35 students from Muhammadiyah 1 Palembang high school in the academic year 2022/2023. Data collection techniques conducted by the research using tests and interviews. The test given to students has a total of 5 questions, with 60 minutes to complete the test. The data in the form of student algebraic argumentation that has been obtained is then analyzed using the Toulmin model argumentation indicators. The Toulmin model argumentation indicators are shown in Table 1.

Table 1. Level of Students' Algebraic Argumentation

Level of Argumentation	Level Category	Total Score	Criteria

1	Not Good	0 – 5	• State the claim clearly and correctly (score +1) • Explaining evidence/data (score +1) • Proof using warrant (score +1) • There is backing that supports (score +1) • The flow of proof is structured (score +1)
2	Less Good	6 – 10	
3	Enough	11 – 15	
4	Good	16 – 20	
5	Very Good	21 – 25	

In analyzing the results using the Toulmin argumentation model as in Table 1. The Toulmin argumentation model is the right choice in analyzing argumentation because in the Toulmin model there are 6 complex components such as claim, data, warrant, backing, qualifier, and rebuttal so that the Toulmin model is very effective in measuring a person's argumentation skills (Afandi et al., 2021). The following is a schematic of the Toulmin model argumentation as shown in Figure 1.

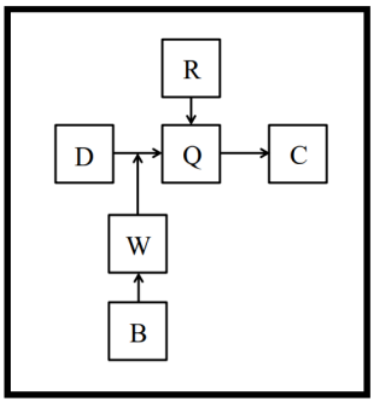

Figure 1. Toulmin model scheme

The structure of argumentation according to Toulmin (2003) scheme has basic statement types, namely claim/conclusion (C), data (D), warrant (W), and backing (B). These basic components are supported by other components, namely rebuttal (R) and qualifiers (Q), which are optional. (Faizah et al., 2021). Data analysis in this study only uses the basic components of the Toulmin model.

RESULT AND DISCUSSION

Data analysis through the process of processing data from student answers and analyzed using Toulmin Model indicators. Each student needs to answer all the questions given, then the results of student answers are analyzed according to the score criteria on the Toulmin Model indicators consisting of claim, data/evidence, warrant, and backing so as to produce an argumentation ability level category. The answers from students are argumentation in written form that informs what students know. Argumentation that can be said to be good if it has a claim as the main argument, then the data is proven to be true (evidence) with the flow of proof structured, then the data and claims are connected through warrant and supported by backing. The results of data analysis show a description of the answers of 35 students from 5 algebraic proof questions that 14.28% of students' mathematical argumentation skills were at level 5; 62.86% of students'

mathematical argumentation skills were at level 4; 20% of students' mathematical argumentation skills were at level 3; 2.86% of students' mathematical argumentation skills were at level 2; and no students were at level 1. Details of the analysis results are shown in Table 2.

Table 2. Result of Students' Algebraic Argumentation

Level of Argumentation	Level Category	Frequency	Percentage
1	Not Good	0	0%
2	Less Good	1	2.86%
3	Enough	7	20%
4	Good	22	62.86%
5	Very Good	5	14.28%

The test results showed that there were 5 students categorized as level 5 with a percentage of 14.28%. Students with very good categories bring up indicators of claim, data, warrant and backing that are arranged systematically. A snapshot of the answers of very good categorized students can be seen in Figure 2.

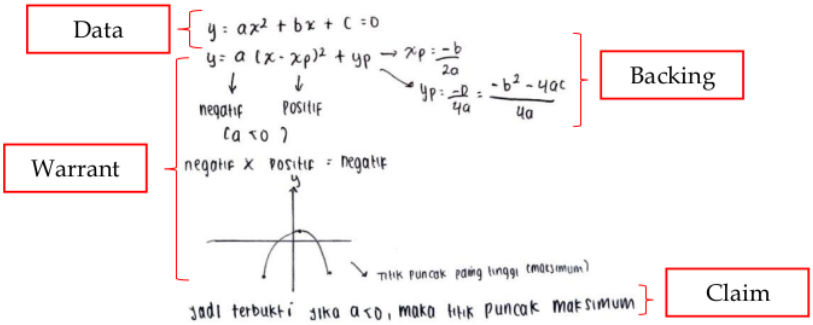

Figure 2. Very good category subject answers

There were 22 students categorized as level 4 with a percentage of 62.86%. Students with good categories only bring up indicators of data, claim, and backing. However, the warrant indicator did not appear in the student's answer. The warrant presented is not correct and not systematic. The warrant provided contained an error in operating the backing. Errors in answering such as in arithmetic operations are included in the technical dimension error (Ulfa & Kartini, 2021). A snapshot of the answers of good categorized students can be seen in Figure 3.

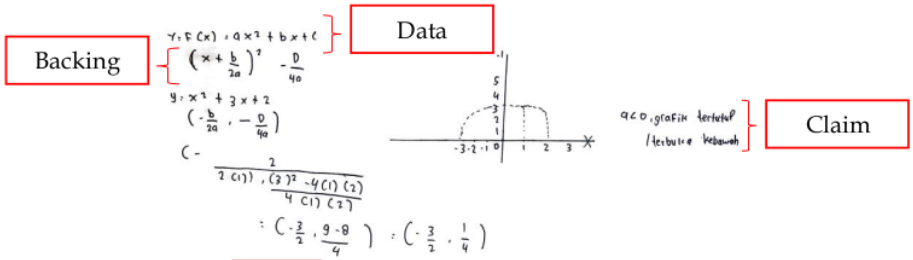

Figure 3. Good category subject answers

There were 7 students categorized as level 3 with a percentage of 20%. Students with enough categories only bring up data and warrant indicators. However, the claim and backing indicators did not appear in the student's answer. A snapshot of the answers of students categorized as enough can be seen in Figure 4.

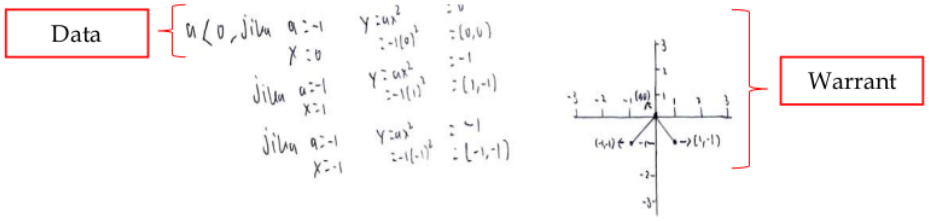

Figure 4. Enough category subject answers

There was 1 student categorized as level 2 with a percentage of 2.86%. Student with less good categories only bring up data indicators. However, the claim, warrant and backing indicators did not appear in the student's answer. Lack of understanding of concepts is included in conceptual dimension errors which are errors when understanding ideas in mathematics (Suhady et al., 2019). A snapshot of the less good categorized student's answer can be seen in Figure 5.

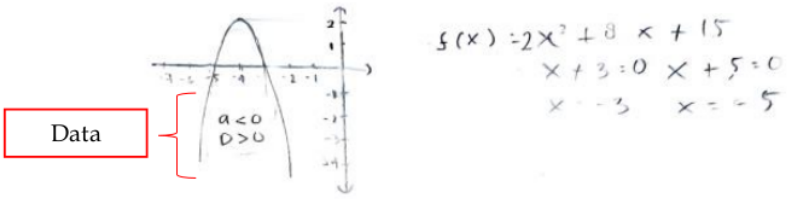

Figure 5. Less good category subject answers

Based on some of the answer snapshots presented, it can be seen that the higher the student's level of argumentation, the better the answer given (Soekisno, 2015). After conducting the test, the researcher interviewed the four subjects as representatives of each category. This interview was conducted to obtain in-depth answers or reasons regarding questions that might not be written on the student's answer sheet (Darmadi, 2011). After the interview was conducted, it was found that the reason from the student in the less good category was that the student had difficulty in answering the question. This is due to the low understanding of his concept of discriminant that makes him unable to provide proof systematically. This is in line with the statement that a student's reasoning and understanding of concepts can be seen from written or oral arguments (Handayani, 2015).

CONCLUSION

Based on the results of research data analysis on students from Muhammadiyah 1 Palembang high school in the academic year 2022/2023, it can be concluded that the average algebraic argumentation ability of students is at level 4 with the category that is good student algebraic argumentation. Students' imperfect algebraic argumentation ability have factors that affect the level of algebraic argumentation ability. The factors that influence this are students experiencing errors in answering (technical dimension error)

and lack of understanding of the concepts and data in the given problem (conceptual dimension error).

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