Analysis of elements of scientific argumentation skills in science textbooks for junior high school students

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Abstract
This study aims to analyze the distribution of scientific argumentation elements based on the Toulmin Argumentation Pattern (TAP) in science teaching materials for grade VII, which includes textbooks and teaching modules. This study uses a qualitative descriptive approach with a content analysis method. The subject of the research is in the form of several science teaching materials used in junior high schools, while the object of research is the element of scientific argumentation which includes claims, data, warrants, backing, qualifiers, and rebuttals. The data collection technique is carried out through documentation, then analyzed using a check sheet based on the Toulmin indicator. The results of the study show that the elements of scientific argumentation in teaching materials have not been evenly distributed. The most dominant elements are claims and warrants, while data appears in moderate proportions. Meanwhile, a limited number of backing and qualifier elements appear, and no rebuttal elements are found. These findings show that the structure of scientific arguments in teaching materials tends to be incomplete and still focuses on the delivery of information and basic reasoning, without encouraging critical evaluation and comprehensive argument development. Thus, it can be concluded that the science teaching materials analyzed have not fully supported the optimal development of students' scientific argumentation skills. Therefore, it is necessary to develop teaching materials that integrate all elements of Toulmin's argumentation in a more balanced manner to improve students' critical and argumentative thinking skills.

1. Introduction

Science education plays a pivotal role in cultivating students' critical thinking and scientific reasoning skills. Science learning is defined by the Organisation for Economic Co-operation and Development (OECD, 2019) as the mastery of concepts in addition to the training of students in the utilisation of scientific knowledge for the explanation of phenomena and the making of evidence-based decisions (García-Carmona, 2025). In the context of the 21st century, these skills are part of the science literacy required to address various problems in daily life (Bybee, 2015). However, research findings indicate that the scientific literacy and scientific reasoning skills of Indonesian students remain comparatively inadequate (OECD, 2019; Pratiwi & Rusilowati, 2020).

In accordance with these demands, the curriculum implemented in Indonesia places emphasis on the development of higher-order thinking skills (HOTS), with a particular focus on critical and argumentative thinking skills (Ministry of Education and Culture, 2022). One such skill is scientific argumentation, defined as the ability to compose, present, and evaluate arguments based on data and logical scientific reasoning (Osborne & Patterson, 2011). Scientific argumentation is regarded as a pivotal element in the pedagogy of science, as it has been demonstrated to facilitate students' comprehension of concepts in a more profound and reflexive manner (Sampson & Blanchard, 2012; Özdem Yilmaz et al., 2017).

In the study of scientific argumentation, the Toulmin Argumentation Pattern (TAP) is one of the frameworks most frequently employed to analyse the structure of arguments (Erduran et al., 2004). The framework under discussion consists of six elements, namely claims, data, warrants, backing, qualifiers, and rebuttals. The structure delineates that a compelling scientific argument encompasses not solely statements and evidence, but also reasoning, theoretical underpinnings, limitations of claims, and potential rebuttals (Allchin & Zemplén, 2020).

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However, the findings of earlier studies indicated that students' proficiency in scientific argumentation remained deficient, particularly with regard to reasoning (warrant) and rebuttal (Rahmawati et al., 2021). Furthermore, the teaching materials employed in the context of science learning have not fully integrated the elements of scientific argumentation. The preponderance of teaching materials is characterised by the presentation of claims and data, with elements of backing, qualifiers, and rebuttals being conspicuously absent (Putri & Widodo, 2019). This finding suggests that students have not been provided with sufficient opportunities to develop scientific arguments in a comprehensive manner.

The role of teaching materials, particularly textbooks and modules, in shaping students' cognitive frameworks and argumentative abilities is of paramount significance (Loper et al., 2025). In the absence of a comprehensive argumentative framework within teaching materials, students often adopt a passive role in the reception of information, resulting in a deficiency in critical thinking skills (Muslich, 2010; Utami & Rahayu, 2021). Consequently, an analysis of the content of scientific argumentation elements in teaching materials is imperative to ascertain the extent to which the teaching materials support the development of students' argumentative skills.

The objective of this study is to analyse the distribution of scientific argumentation elements based on the Toulmin Argumentation Pattern in science teaching materials for grade VII. The results of this study are expected to provide an overview of the quality of the argumentation structure in teaching materials and become the basis for the development of teaching materials that better support students' critical thinking and scientific argumentation skills.

2. Method

This study uses a qualitative descriptive approach with a content analysis method. This approach is used to identify and analyze the elements of scientific argumentation in teaching materials systematically (Krippendorff, 2018). This study aims to identify and analyze elements of scientific argumentation based on the Toulmin Argumentation Pattern (TAP) in science teaching materials in class VII (Erduran et al., 2004).

The research subject is in the form of science teaching materials consisting of textbooks and teaching modules used at the junior high school level. The object of research is the element of scientific argumentation which includes claims, data, warrants, backing, qualifiers, and rebuttals (Toulmin, 2003).

The data collection technique is carried out through documentation studies by identifying, classifying, and recording parts in teaching materials that contain elements of scientific argumentation (Sugiyono, 2019). The research instrument used was in the form of an analysis checklist sheet compiled based on Toulmin element indicators.

The data analysis technique is carried out through several stages, namely: (1) data reduction by grouping findings based on argumentation elements, (2) presenting data in the form of frequency and percentage distribution tables, and (3) drawing conclusions based on the distribution pattern of the found argumentation elements (Miles et al., 2014).

The validity of the data in this study is maintained through theoretical triangulation techniques and discussions with experts to ensure the suitability of the results of the analysis with the scientific argumentation concepts used (Lincoln & Guba, 1985; Donkoh & Mensah., 2023).

3. Results and Discussion

The results of the analysis show that the distribution of scientific argumentation elements in science teaching materials for grade VII is not even and tends to be dominated by certain elements. The most common elements that appear are claims and warrants, while data elements appear in moderate proportions. Meanwhile, backing and qualifier elements were found in limited quantities, and rebuttal elements were not found in the teaching materials analyzed.

The dominance of the claim element shows that the teaching material presents more explicit scientific statements or concepts. This indicates that learning is still oriented towards the delivery of

information, where students tend to receive knowledge without going through an in-depth argumentation process. The existence of a sufficiently high warrant element indicates that there is an attempt to explain the logical relationship between data and claims. However, this explanation has not been fully supported by adequate backing elements.

The appearance of data elements in moderate proportions shows that not all claims in teaching materials are supported by clear empirical evidence. In fact, in scientific argumentation, data has an important role as a basis for building valid claims. The lack of backing elements shows that theoretical support or scientific concepts that strengthen reasoning are still not presented explicitly.

In addition, the low occurrence of qualifier elements suggests that most claims are presented without clear limitations or levels of certainty. This has the potential to lead to an absolute understanding, whereas in science, the truth of a statement is often contextual and depends on certain conditions. The absence of a rebuttal element shows that the teaching material has not provided space for students to develop the ability to refute or critically evaluate a claim. The absence of this element indicates that the structure of the argument presented is still one-way and has not encouraged students to consider alternatives or other possibilities in a scientific problem.

When reviewed based on the type of teaching material, the material tends to have more complete argumentation elements than activities and questions. In the material section, the backing and qualifier elements can still be found even though they are limited, while in the activities and questions section, the two elements almost do not appear. This shows that the structure of scientific argumentation has not been thoroughly integrated in all components of teaching materials.

The results of the analysis of scientific argumentation elements in science teaching materials for grade VII are presented in Figure 1 to Figure 4. In general, the distribution of scientific argumentation elements shows an uneven pattern and is still dominated by certain elements.

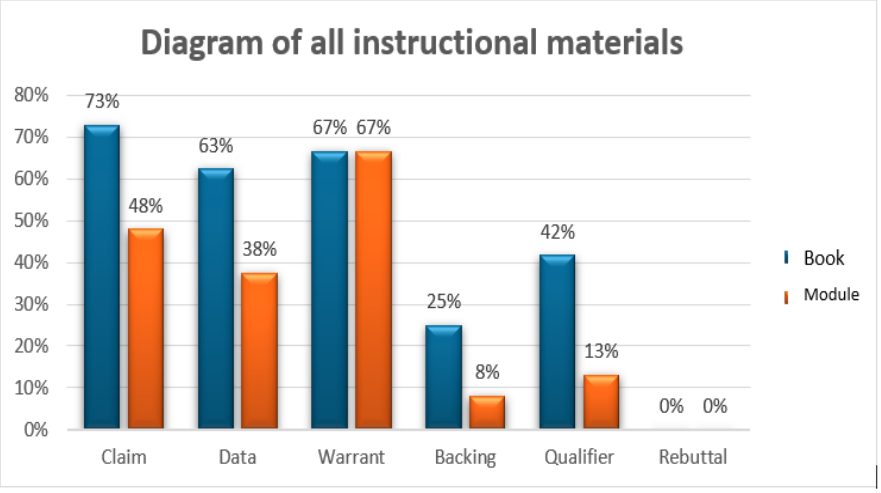

Figure 1. Percentage of Emergence of Scientific Argumentation Elements of All Teaching Materials

Based on Figure 1, it can be seen that the claim element has the highest percentage in the book at 73% and in the module at 48%. The warrant element also shows a high percentage, which is 67% in both books and modules. Meanwhile, data elements appear 63% on books and 38% on modules. In contrast, backing and qualifier elements appear in lower numbers, at 25% and 42% on books, and 8% and 13% on modules, respectively. The rebuttal element was not found in both types of teaching materials (0%). These findings show that the structure of scientific arguments in teaching materials in general is still incomplete, especially in the elements that play a role in strengthening and evaluating arguments. Next. percentage of emergence of elements of scientific argumentation teaching materials 1 can be seen in Figure 2.

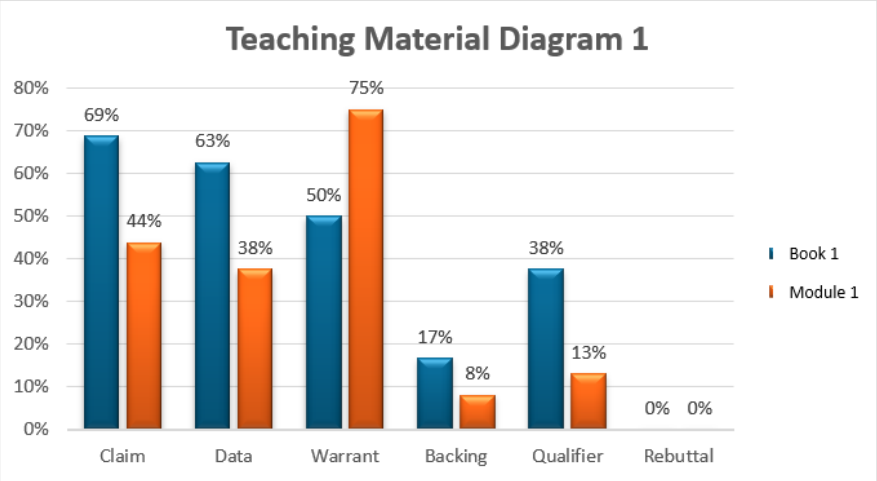

Figure 2. Percentage of Emergence of Elements of Scientific Argumentation Teaching Materials 1

If you look at it in more detail, in Teaching Material 1 (Figure 2) it can be seen that the claim element in the book reaches 69% and the module 44%, while the warrant element shows a significant difference, namely 50% in the book and increases to 75% in the module. Data elements appear 63% on books and 38% on modules. Meanwhile, the backing and qualifier elements are still low, namely 17% and 38% in books, and 8% and 13% respectively in modules. The rebuttal element is not found. This shows that despite efforts to explain logical relationships through warrants, strengthening arguments through backing and restricting claims through qualifiers is still not optimal. Figure 3 shown a percentage of emergence of elements of scientific argumentation teaching materials 2.

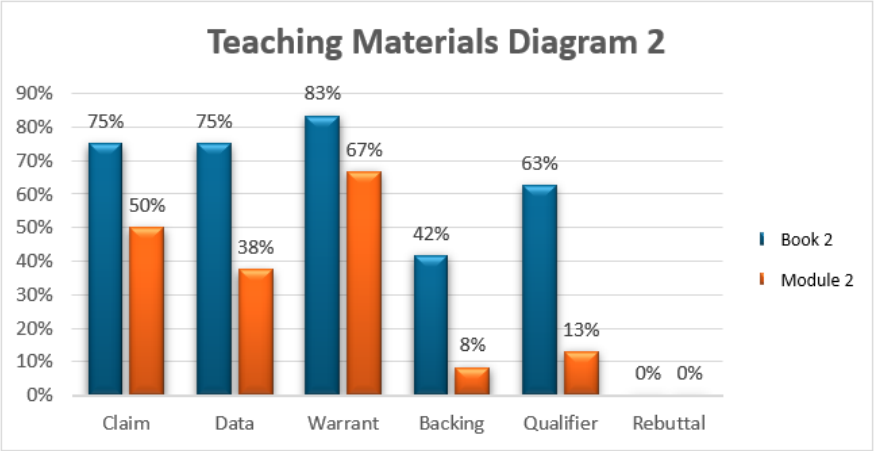

Figure 3. Percentage of Emergence of Elements of Scientific Argumentation Teaching Materials 2

In Teaching Material 2 (Figure 3), the distribution of argumentation elements shows a higher tendency than other teaching materials. The claim elements and data on the book each reached 75%, while warrants reached 83%. In the module, the claim element is 50%, data is 38%, and warrant is 67%. Interestingly, the backing element on the book increased to 42%, although in the module it remained low (8%). The qualifier element in the book is also quite high, which is 63%, while in the module it is 13%. However, the rebuttal element remains unfounded. This shows that Teaching Material 2 has a relatively more complete argumentation structure, although it still does not cover all of Toulmin's elements in its entirety. Figure 4 shown a percentage of emergence of elements of scientific argumentation teaching materials 3.

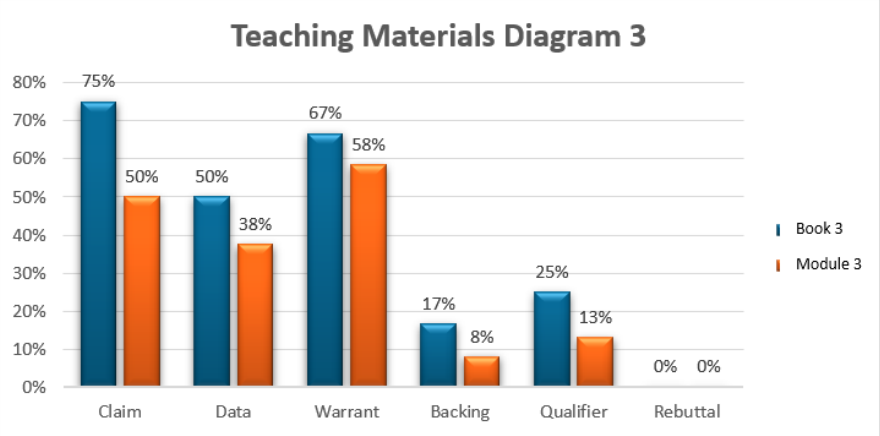

Figure 4. Percentage of Emergence of Elements of Scientific Argumentation Teaching Materials 3

Meanwhile, in Teaching Material 3 (Figure 4), the claim element in the book reached 75% and the module 50%, while the warrant element was 67% in the book and 58% in the module. Data elements appear at 50% on the book and 38% on the module. The backing and qualifier elements again showed a low percentage, namely 17% and 25% respectively in books, and 8% and 13% in modules. The rebuttal element was not found. These findings show that the distribution pattern of argumentation elements in Teaching Materials 3 is still similar to other teaching materials, namely dominance in the basic elements and minimal in the reinforcement and evaluation elements.

Overall, the results of this study show that science teaching materials emphasize more on the elements of claim, data, and warrant, which are the basic structures in scientific argumentation (Erduran et al., 2004). However, the backing and qualifier elements are still limited, and the rebuttal elements are not found at all. This condition indicates that the arguments presented in the teaching materials are still one-way and have not encouraged students to critically evaluate a claim (Osborne & Patterson, 2011).

These findings are in line with previous research that states that science teaching materials tend to focus on the delivery of concepts rather than the development of comprehensive scientific arguments (Putri & Widodo, 2019; Sampson & Blanchard, 2012). The lack of backing elements indicates a lack of theoretical support in reinforcing reasoning, while the low qualifier indicates that claims are often presented without clear boundaries (Erduran et al., 2004). The absence of the rebuttal element indicates that students have not been facilitated to develop the ability to refute or critically evaluate arguments (Rahmawati et al., 2021).

Thus, the teaching materials analyzed have not fully supported the optimal development of students' scientific argumentation skills. Therefore, it is necessary to develop teaching materials that explicitly integrate all elements of Toulmin's argumentation so that students can build more complete, logical, and critical scientific arguments (Sampson & Blanchard, 2012).

4. Conclusion

Based on the results of the research, it can be concluded that the distribution of scientific argumentation elements in science teaching materials for grade VII has not been optimally integrated. The most dominant elements are claims, data, and warrants which show that teaching materials focus more on the delivery of information and basic reasoning (Erduran et al., 2004). Meanwhile, backing and qualifier elements still appear in limited proportions, and rebuttal elements are not found in all teaching materials analyzed (Rahmawati et al., 2021).

This condition indicates that the structure of scientific argumentation in teaching materials is still partial and does not reflect a complete argumentation pattern according to the Toulmin Argumentation Pattern framework (Toulmin, 2003). As a result, teaching materials have not fully supported the development of students' critical thinking skills and scientific argumentation (Osborne & Patterson, 2011). Therefore, it is necessary to develop science teaching materials that explicitly

integrate all elements of scientific argumentation, especially backing, qualifiers, and rebuttals, so that students can build more comprehensive, logical, and critical arguments (Sampson & Blanchard, 2012). Further research is suggested to develop and test the effectiveness of teaching materials based on scientific argumentation in improving students' critical thinking skills.

Author Contributions

The first author plays a role in research design, data collection, data analysis, and article manuscript writing. The second and third authors contribute to research guidance, instrument validation, and manuscript review and refinement. All authors have read and approved the final version of the manuscript.

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Declaration of Conflicting Interests

The author declared no potential conflicts of interest with respect to the research, authorship, and/ or publication of this article.

Data Availability

The datasets generated during and/ or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration on AI Use

The authors declare that no artificial intelligence (AI) or AI-assisted tools were used in the preparation of this manuscript.

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