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Application of The Scientific and Technological Argumentation Group Learning Model (GARIT) To Improve Students' Argumentation Skills in Physics Learning

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Abstract: This research to evaluate the influence of the Scientific Technology Argumentation Group (GARIT) learning model on students' argumentation skills in the context of physics learning. The research method used is a quantitative method with a pre-experimental design using the One-Group Pretest-Posttest Design type. The research was conducted over five meetings, where one meeting was filled with a pre-test, three meetings with the application of the GARIT learning model, and one meeting with a post-test. The duration of each meeting is 2×40 minutes. Data is collected at each meeting to assess teacher and student activities using teaching modules focused on Global Warming material. The research results showed a significant increase in students' argumentation skills after implementing the GARIT learning model. Data analysis shows positive changes in indicators, especially in warrant ground and qualifier. However, the increase in claims and rebuttal indicators tends to be lower. From the results of the hypothesis test, it was concluded that the GARIT learning model had a significant influence on students' argumentation skills on Global Warming material. In the context of physics learning, the application of the GARIT model shows the potential to improve students' abilities in scientific reasoning. The conclusion of this research confirms that the Scientific Technology Argumentation Group (GARIT) learning model can positively influence students' argumentation skills in physics learning, especially related to the topic of Global Warming.

Keywords: GARIT Learning Model, Toulmin Argument Pattern, Scientific Argumentation Skills

Introduction

Scientific argumentation skills refer to the ability to construct strong, logical, and rational arguments within a scientific context, supported by relevant evidence (J. Osborne & Pimentel, 2023; Rapanta, 2021; Rapanta et al., 2021; Zakaria et al., 2025). These skills involve not only presenting opinions but also evaluating evidence, identifying assumptions, and considering multiple perspectives. In both academic and professional settings, such skills are essential for engaging critically in scientific discourse and making evidence-based decisions. The application of scientific argumentation is particularly crucial in science, technology, engineering, and various other disciplines that emphasize research and problem-solving (Fischer et al., 2014; Jiménez-Aleixandre & Erduran, 2007; Jonassen &

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Cho, 2011). Consequently, mastering these skills contributes to the enhancement of critical thinking and the advancement of scientific knowledge.

Many individuals face challenges in developing effective scientific argumentation skills. These challenges can stem from various factors, including a lack of formal education in science and research methodologies, which leads to limited understanding of how to construct strong arguments supported by relevant scientific evidence (Nurroniah et al., 2025; Qolbi et al., 2024; Sadler, 2004). Additionally, restricted access to adequate learning resources and insufficient experience in engaging in scientific discussions can further hinder the development of these skills. Such barriers make it difficult for individuals to critically evaluate evidence, identify weaknesses in arguments, and construct logically coherent statements. Therefore, a systematic educational approach is needed to equip individuals with both conceptual understanding and practical competencies in scientific argumentation.

One of the reasons students tend to dislike physics as a subject is the use of less engaging teaching methods. Teacher-centered approaches, such as lecture-based instruction, often make students feel bored and less motivated to actively participate in the learning process. Such methods tend to overlook student engagement, limiting opportunities for them to ask questions, engage in discussions, and build critical understanding. Consequently, students have insufficient space to develop argumentation skills, which are essential in physics learning. Therefore, the implementation of more interactive and participatory teaching strategies is needed to foster student engagement, enhance motivation, and strengthen critical thinking skills.

When physics content is presented only in a theoretical manner without considering students' levels of understanding, the learning process becomes less effective. Without an initial discussion to explore how well students comprehend the material, they often feel left behind and confused during lessons. This situation makes the content appear disconnected from real-world contexts and unrelated to phenomena encountered in daily life. As a result, students struggle to link abstract concepts with concrete experiences, leading to decreased motivation to learn. Therefore, a more contextual and dialogical teaching approach is necessary to help students connect physics concepts with their real-life experiences.

Many students feel bored during physics lessons due to difficulties in understanding the material (Ady & Warliani, 2022; Irvani et al., 2024; Syahdah & Irvani, 2023). Moreover, they often experience confusion when dealing with assigned tasks, particularly when the learning tools provided fail to adequately support comprehension. This situation not only decreases students' interest in learning but also hinders the development of critical thinking and problem-solving skills. The inadequacy of instructional media and strategies further prevents students from connecting physics concepts to their real-life experiences. Therefore, innovations in the design of learning materials and teaching methods are necessary to better align with students' needs and levels of understanding.

Addressing these challenges requires providing adequate education, training, and learning opportunities, including the implementation of appropriate instructional models, to help students and university learners develop strong scientific argumentation skills (Fitriyani et al., 2025; Muhajir et al., 2021). Such an approach is expected to equip learners with the ability to express ideas logically, critically evaluate information, and construct arguments supported by relevant evidence. Implementing instructional strategies that emphasize the development of argumentation skills will also enhance students' confidence in communicating their ideas. Consequently, they will be better prepared to actively participate in scientific discussions, conduct high-quality research, and present persuasive arguments across various academic and professional contexts (Nuraeni et al., 2025; Sulastri et al., 2024). Ultimately, these efforts contribute to improving the quality of education and fostering learners' intellectual capacity.

The purpose of this study is to implement the Scientific Argumentation Group with Technology (GARIT) learning model in physics instruction to enhance students' argumentation skills. This model is designed to foster active student engagement in group discussions, evaluate evidence, and construct logical, evidence-based arguments. Through the application of GARIT, students are expected to develop critical thinking abilities, articulate ideas systematically, and strengthen their understanding of physics concepts through collaborative interactions. This study aims to contribute to the development of innovative learning strategies that align with 21st-century educational needs, particularly in improving scientific argumentation competencies in physics education.

Method

This study employed a quantitative approach using a quasi-experimental design with a one group pretest-posttest model (Amarulloh & Irvani, 2025). This design was chosen to measure the changes in students' scientific argumentation skills before and after the implementation of the Scientific Argumentation Group with Technology (GARIT) learning model. The research was conducted at a senior high school in Garut Regency, involving one class consisting of 27 tenth-grade students as the research subjects. The class was selected purposively based on the school's recommendations and the suitability of student characteristics with the research needs.

The research instrument consisted of essay-based tests designed to measure students' scientific argumentation skills in physics. These instruments underwent validity testing to ensure alignment with the indicators of argumentation skills, as well as reliability testing to guarantee measurement consistency. The research procedure began with a pretest to assess students' initial abilities, followed by the implementation of the GARIT learning model over several sessions, and concluded with a posttest to evaluate improvements in argumentation skills. The test results were analyzed quantitatively to assess the effectiveness of the implemented learning model.

The scientific argumentation skills test used in this study was developed based on five key aspects of argumentation, namely claim, warrant, ground, qualifier, and rebuttal. These components represent essential elements in constructing a comprehensive scientific argument, ranging from the statements made, supporting reasoning, relevant evidence, limitations of the claim, to counterarguments against opposing views. The test consisted of five essay questions designed to assess students' ability to develop scientific arguments in accordance with these five aspects. Thus, the instrument measured not only students' understanding of physics concepts but also their critical thinking and ability to construct arguments systematically.

Result and Discussion

As explained earlier, there are five aspects measured in the scientific argumentation skills test. The pre- and post-test results for each aspect are described below.

Claim Aspect

The accuracy of claims, refers to a statement or position that one seeks to prove or support within an argument (Mökander et al., 2024; Wiltshire & Ronkainen, 2021). A claim constitutes the core of what is intended to be demonstrated or debated. In this test, there are two items related to claims, specifically items number 1 and 6. The results of the Pretest and Posttest scores for claims are presented in Figure 1.

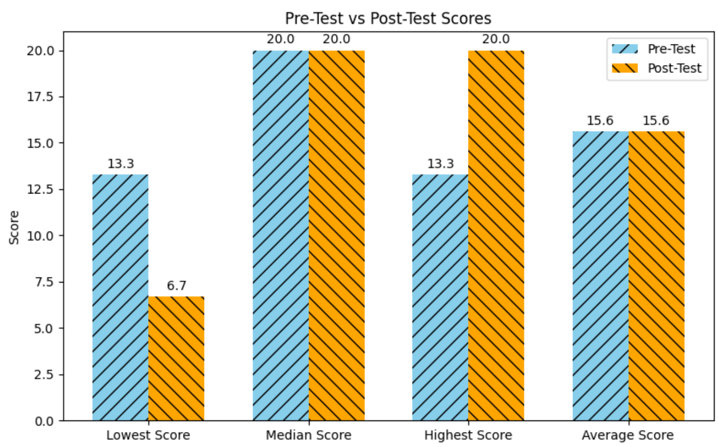

Figure 1. Graph of Scientific Argumentation Skills Test Results: Claim Aspect

From the Figure 1, based on the pretest and posttest administered to 27 samples, three categories of improvement were identified: low, moderate, and significant. The data were classified into these categories based on the understanding that a claim represents the outcome of established values, opinions regarding a given situation, or an assertion of a particular standpoint. Justification refers to the rules and principles that explain the relationship between data and claims, leading to the conclusion that a claim constitutes a statement of a phenomenon or an opinion derived from the interpretation of that phenomenon (Ady et al., 2024; Heryanto et al., 2023; Rapanta, 2021). From the highest score in the table, it can be concluded that there was an increase from 13.3 to 20. This improvement is attributed to the treatment that emphasized group-based argumentation supported by scientific literature and other credible sources. Previous research also indicates that the claim aspect tends to achieve the highest score, showing that among the six components of Toulmin's Argument Pattern (TAP), the largest proportion is typically obtained from claims (Fretes et al., 2025; Greenberg et al., 2021; Zhdanava et al., 2021). Thus, although there was an increase in average scores for this aspect, the change was not statistically significant.

Warrant Aspect

The quality of a warrant refers to the line of reasoning or assumptions that connect a claim to the data or evidence used. A warrant explains why or how the data support the proposed claim (Henukh et al., 2024; M. J. Osborne, 2004; Rahmawati et al., 2021; Toulmin, 2003). In this test, there were two items related to warrants, specifically items number 2 and 7. The results of the Pretest and Posttest scores for warrants from 27 students are presented in Figure 2.

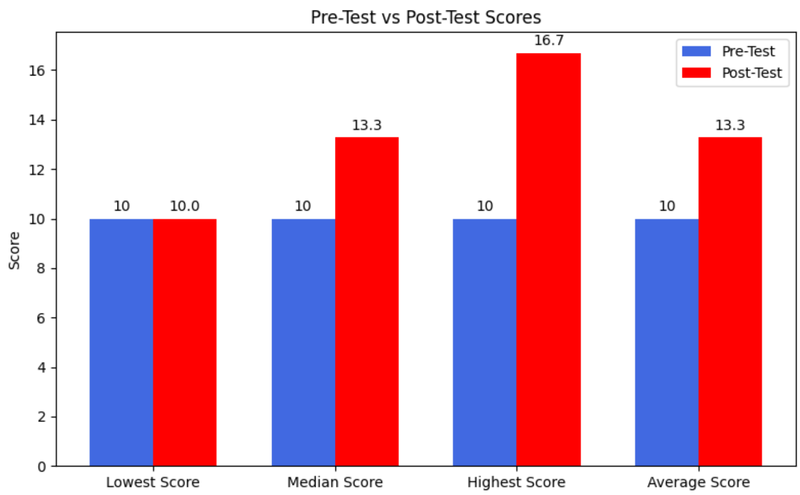

Figure 2. Graph of Scientific Argumentation Skills Test Results: Warrant Aspect

The results of the pretest and posttest for the warrant indicator showed an increase in the posttest scores; however, the improvement was not statistically significant. This is because warrants primarily involve providing logical justifications and arguments to support previous statements. These findings are consistent with previous research, which states that in writing warrants, students are only required to connect data and statements so that the problems can be properly resolved in accordance with the underlying theory (Erduran et al., 2004; Jiménez-Aleixandre & Erduran, 2007). From the graph, based on the pretest and posttest administered to 27 samples, the average scores increased from 10 to 13.3, resulting in a difference of only 3.3 from the maximum score. This limited improvement is attributed to the fact that the participants already demonstrated consistent justification based on scientific data, resulting in valid and evidence-based arguments that met the criteria for warrants.

Ground Aspect

According to Osborne (2004), grounds or data refer to information, facts, or evidence that support a proposed claim. Grounds serve as the basis or rationale for considering a claim to be valid or relevant. In this test, there were two items related to grounds, specifically items number 3 and 8. The recap of the average scores from 27 students is presented in Figure 3.

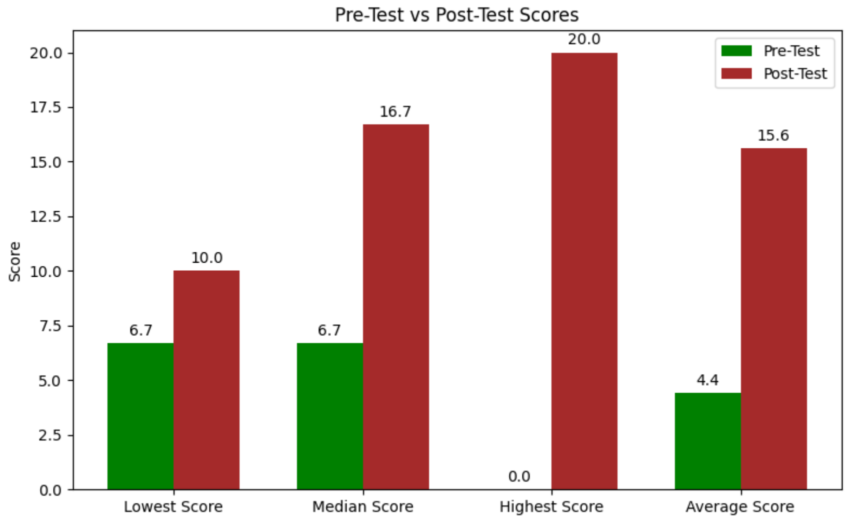

Figure 3. Graph of Scientific Argumentation Skills Test Results: Ground Aspect

The average pretest and posttest scores for the grounds indicator showed a significant increase after the treatment. This finding is consistent with previous research, which stated that students were already fairly proficient in connecting obtained information with written responses as evidence to strengthen and validate their claims (Belland et al., 2008, 2011; Sandoval & Millwood, 2005). The considerable increase in scores after the treatment may be attributed to several factors, one of which is that these items were relatively challenging, requiring critical reasoning and scientifically valid arguments. Following the implementation of the GARIT learning model, it can be concluded that students became more accustomed to connecting information with their written responses, thereby strengthening their claims and making them more acceptable.

Qualifier Aspect

The quality of a qualifier lies in its function to restrict or clarify a claim by adding solutions or alternative approaches to address a problem, often accompanied by an indication of the level of certainty or limitations of the proposed claim. In this test, there were two items related to qualifiers, specifically items number 4 and 9. The results of the Pretest and Posttest scores for qualifiers from 27 students are presented in Figure 4.

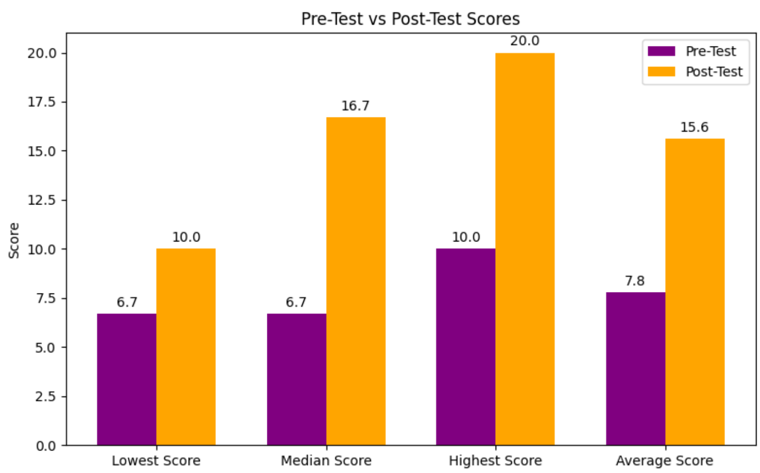

Figure 4. Graph of Scientific Argumentation Skills Test Results: Qualifier Aspect

The average pretest and posttest scores for the qualifier indicator, which serves to clarify claims by adding solutions or alternative approaches to address a problem—often accompanied by an indication of the level of certainty or limitations of the proposed claim—showed a substantial increase after the treatment. The accuracy of solutions can thus be measured by evaluating the problem-solving approaches derived from the claims. This finding is consistent with the view that systematic problem-solving provides guidance for taking actions that help individuals resolve issues effectively (Irvani et al., 2017; Juárez & Guzmán, 2022; Nurdini et al., 2025). Based on these results, the researchers inferred that the implementation of the GARIT learning model enabled students to better identify the connection between a claim and an appropriate solution, thereby improving the accuracy of the proposed solutions. This conclusion is supported by the considerable increase in posttest scores compared to pretest scores. Given that the related test items were of moderate difficulty, the results indicate that students demonstrated improvement in providing quality solutions and alternative approaches to the problems presented.

Rebuttal Aspect

The accuracy of a solution serves as an important consideration in presenting a qualifier, as it involves evaluating the potential rejection of the proposed qualifier. This process accounts for alternative arguments as well as the strengths and weaknesses that need to be addressed in an argument. In this test, two items were related to the rebuttal component. The results of the Pretest and Posttest scores for rebuttals from 27 students are presented in Figure 5.

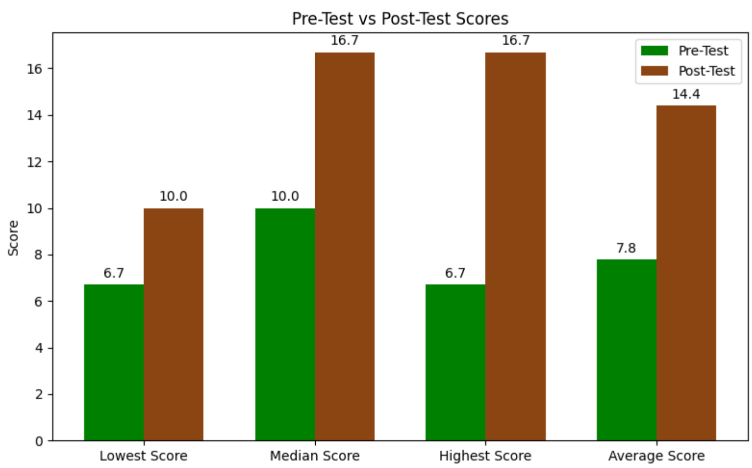

Figure 5. Graph of Scientific Argumentation Skills Test Results: Rebuttal Aspect

The findings indicate that the students were able to present solutions with appropriate, comprehensive, and scientifically valid reasoning. The samples demonstrated accurate solutions in formulating consistent qualifiers supported by empirical data. As a result, the solutions provided were accompanied by logical arguments that aligned with scientific facts.

The analysis of students' argumentation skills using Toulmin's Argument Pattern (TAP), which includes claim, warrant, grounds, qualifier, and rebuttal, showed varying levels of improvement after the implementation of the GARIT learning model. For the claim component, there was a slight increase in students' ability to formulate statements representing the core of their arguments, though the improvement was not statistically significant, indicating that students still faced challenges in articulating strong and debatable positions (Erduran et al., 2004; Jiménez-Aleixandre & Erduran, 2007; Tar et al., 2007). In the warrant component, which reflects the reasoning that connects data to claims, the increase in scores was minimal, suggesting that students' justifications remained limited to logical connections without broader elaboration (Rapanta, 2021; Toulmin, 2003). In contrast, a significant improvement was observed in the grounds component, as students demonstrated greater proficiency in using evidence to support their claims, showing the effectiveness of the GARIT model in fostering evidence-based reasoning (Handayani et al., 2023; M. J. Osborne, 2004; Paling et al., 2024). For qualifiers, which clarify claims by acknowledging certainty levels or alternative solutions, posttest scores showed a substantial increase, indicating that students became more adept at framing arguments within appropriate boundaries and considering alternative problem-solving approaches (Bächtold et al., 2023; Whitworth & Wheeler, 2017). Lastly, the rebuttal component also showed a notable improvement, reflecting enhanced critical thinking skills as students learned to anticipate counterarguments and refine their arguments accordingly. Overall, these findings demonstrate that the GARIT learning model effectively improved students' argumentation skills, particularly in constructing evidence-based reasoning, clarifying claims with qualifiers, and addressing counterarguments, while modest gains in claims and warrants suggest the need for further targeted interventions to strengthen these aspects.

Conclusion

The implementation of the Scientific and Technological Argumentation Group Learning Model (GARIT) has proven effective in improving students' scientific argumentation skills in physics learning, particularly on the topic of global warming. The results of the pretest and posttest analyses across five indicators of Toulmin's Argument Pattern (claim, warrant, grounds, qualifier, and rebuttal) demonstrate overall positive progress. The most significant improvements were observed in the grounds, qualifier, and rebuttal components, reflecting enhanced abilities in evidence-based reasoning, framing arguments with appropriate levels of certainty, and addressing counterarguments. Although the gains in the claim and warrant components were more modest, the overall findings indicate that the GARIT model successfully encouraged students to engage in collaborative discussions, construct logical arguments, and connect their reasoning with credible evidence.

These results highlight the potential of the GARIT learning model as an innovative instructional approach to foster critical thinking and scientific reasoning in physics education. By emphasizing group argumentation, the model provided opportunities for students to actively engage in dialogue, evaluate alternative perspectives, and refine their arguments based on evidence. Future research is recommended to explore the application of this model across different scientific topics and educational levels, as well as to develop strategies that can further strengthen the components with lower improvement, such as claims and warrants. Overall, this study confirms that integrating argumentation-focused learning models can contribute significantly to enhancing students' higher-order thinking skills and engagement in science learning.

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