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Argument-Driven Inquiry in Improving the Scientific Argumentation Skills of Grade 10 Students

Jason M. Cantilado[a], Dr. Elisa N. Chua[b]

[a]0319-3273@lspu.edu.ph , elisa.chua@lspu.edu.ph [b]
[a]Nabangka National High School, Guinayangan, Quezon, 4319, Philippines
[b]Laguna State Polytechnic University- San Pablo City Campus, San Pablo City, Laguna, 4000, Philippines

Abstract

The pervasive issue of low proficiency in science education among Filipino learners can be addressed by implementing the Argument-Driven Inquiry (ADI) model. This study aims to enhance the scientific argumentation skills of Grade 10 students using ADI. It investigates learners' cognition, misconceptions in third-quarter science lessons, and their experiential exposure through concrete experience, reflective observation, abstract conceptualization, and active experimentation. The research evaluates the effectiveness of ADI lesson exemplars concerning clear learning objectives, building on prior knowledge, engaging opening activities, effective instructional strategies, and closure. Furthermore, it assesses the pre- and post-performance of students' scientific argumentation skills, focusing on claims, evidence, and reasoning, and examines significant differences in performance after implementing ADI lessons. Employing a descriptive-developmental research design, 63 Grade 10 students from Nabangka National High School were purposively selected. Various instruments, including a multiple-choice exam, two-tier True or False test, and survey questionnaires, were validated and administered to gather data. The study spanned February and March 2024, involving pre-assessment, ADI lesson execution, and post-assessment. Results indicate varied cognitive abilities, highlighting the need for targeted educational interventions. High misconceptions necessitate corrective instructional strategies, and low experiential exposure suggests a need for higher-order thinking activities. ADI lesson exemplars effectively engaged students and improved their scientific argumentation skills, with significant gains in claims, evidence, and reasoning. Positive feedback from students underscored improvements in investigative skills and collaborative learning experiences, validating the efficacy of ADI in fostering critical scientific skills and deeper learning retention.

Keywords: Argument-driven Inquiry, Scientific Argumentation Skills

1. Introduction

In the Philippines, one of the primary agendas of the Department of Education is to strengthen science education. This is evident in the K to 12 science curricula, which emphasize the need for learners to demonstrate an understanding of science concepts and the application of science inquiry skills—both essential for becoming scientifically literate individuals. According to the Organization for Economic Cooperation and Development (OECD), a scientifically literate person should be able to interpret and make sense of basic scientific data and evidence used to make claims and draw conclusions.

One significant component of scientific literacy is scientific argumentation, which supports student involvement in authentic science learning by constructing, evaluating, and refining scientific claims through various methods, practices, reasoning, and reflective participation (Purnomo et al., 2023). Scientific argumentation involves understanding and applying argumentation skills, engaging students in producing evidence, testing and evaluating theories, and communicating like scientists. Therefore, enhancing these skills can directly contribute to the primary goal of the K to 12 curriculum by promoting a deeper understanding and application of scientific concepts.

Scientific argumentation is essential for developing and refining scientific knowledge. It fosters engagement in scientific practices and enhances content knowledge (Dogomeo & Aliazas, 2022). This skill is crucial for students to understand scientific concepts and the nature of scientific processes carried out by scientists (Grooms et al., 2015). Training students in argumentation skills is vital for developing clear views, logical reasoning, and rational explanations of the material. These skills equip students to explain everyday scientific phenomena based on science concepts (Ginanjar & Utari, 2015). Given the emphasis on scientific literacy within the K to 12 curricula, focusing on argumentation skills aligns with national educational goals and helps address current educational gaps.

The OECD's 2023 Programme for International Student Assessment (PISA) revealed that Filipino pupils performed poorly in math and science, ranking lower overall among 80 participating countries. Similarly, the Trends in International Mathematics and Science Study (TIMSS) 2019 results showed that the Philippines scored significantly lower in science (249) and mathematics (297) compared to other nations. These studies highlight the need to improve the quality of the educational system in the Philippines and find effective educational strategies that address students' needs. Improving scientific argumentation skills could be a critical component of this improvement, as it directly impacts students' ability to engage with and understand scientific material.

Research by Fakhriyah (2021) indicates that the Argument-Driven Inquiry (ADI) learning model can improve learners' scientific argumentative skills. According to Sampson et al. (2013), as cited by Sengul et al. (2021), the ADI model helps teachers create classroom environments that facilitate explicit argumentation. Designed with social constructivist theories, the ADI model integrates laboratory investigations and engages students in science and engineering practices while emphasizing science content, the nature of science, and crosscutting concepts. Implementing the ADI model could therefore address both the need for better scientific literacy and the specific challenges identified by PISA and TIMSS.

Based on these discussions, the researcher conceived the idea of enhancing the scientific argumentative skills of grade 10 students using argument-driven inquiry lesson exemplars. This approach aligns with the K to 12 curriculum goals and addresses the identified deficiencies in scientific education in the Philippines, potentially leading to improved student performance in national and international assessments.

1.1 Students Misconceptions

According to Martin et al. (2001), as cited by Soeharto et al. (2019), misconceptions are ideas or insights from students who provide incorrect meaning constructed based on an event or personal experience.

According to Allen (2014), Science misconceptions are individual knowledge gained from educational experience or informal events that are irrelevant or do not have meaning according to scientific concepts. Additionally, misconceptions in science can be described as student ideas from life experience or informal education, which need to be structured better and result in the incorrect meaning according to a scientific concept Soeharto et al., (2019).

Malaterre et al. (2023) revealed in their study that scientific misconceptions can lead to erroneous claims and spread falsity through chains of ill-grounded inferences. Because scientists themselves hold them and precisely work on formulating and justifying knowledge claims, one cannot exclude the possibility that these misconceptions appear somewhere within the premises of other scientific inferences, thereby leading to other false claims and misconceptions. As a result, internal misconceptions pose a direct threat to knowledge.

According to Kurtulus and Tatar (2021), 1 Misconceptions, which refer to the representations or conceptions acquired mostly in informal settings, hinder meaningful learning. This suggests that teachers need to start their lessons by first revealing the learner's previously gained ideas about different science concepts before giving the major idea of the topic; it will help the students understand the topic more and avoid another misconception. Additionally, it also the reason why it is also important that researchers identify what learners' misconceptions in science are, how they are formed, the sources of these misconceptions, and how they can be overcome Kurtulus and Tatar (2021)

Campbell et al.'s study (2013) emphasized the importance of examining student misconceptions and correcting them with sense-making activities. These activities engage students in science and engineering practices that will help them develop their understanding of disciplinary core ideas and crosscutting concepts and, subsequently, the world around them.

1.2 Argument-Driven Inquiry

According to Purnomo et al. (2023), argument-driven inquiry (ADI) was developed by Sampson et al. (2009) as an integrated learning unit to encourage students to participate in interdisciplinary work to enhance their' understanding of essential and practical concepts. The ADI instructional model is not designed to be a curriculum; rather, it is designed to serve as a template or a guide that instructors can use to create school science laboratory experiences that are more authentic and educative for students. This model is designed to be a more authentic approach to laboratory instruction than the “cookbook”-style activities that teachers often use because it provides students with an opportunity to engage in the practices of science (Sampson et al., 2013).

According to Walker et al. (2016), the Argument-Driven Inquiry model (ADI) is a new model underlying the roles of argumentation and inquiry in scientific education. It is an oriented learning model of inquiry syntax. Additionally, they found that ADI allowed learners to improve their attitudes toward science and skills to argue significantly, design, investigate, analyze, and interpret data.

Demircioglu and Ucar's (2015) argument-driven inquiry (ADI) learning model is a laboratory-based learning model that encourages students to engage in experimental and scientific argumentation activities. By applying ADI learning, students are expected to practice their scientific argumentation skills (Noviyanti, 2020).

Demircioglu and Ucar (2015), claim that ADI can establish a more active learning atmosphere by inviting learners to participate in the learning process. It is important because investigating science teaching will contribute to science process skill development in a laboratory.

According to Sampson et al. (2013), as cited by Fakhriyah et al. (2021), the ADI learning model allows learners to argue actively based on the surrounding observable phenomena in the laboratory. Learning with the ADI model improves learners' science process skills, scientific—argumentative writing skills, and argument quality.

Cetin and Eymur (2017) proved that ADI allowed learners to engage with severe scientific presentation practices, such as preparing, presenting, and revising their presentation; learners were also facilitated to develop scientific presenting skills. Additionally, Erenler and Cetin (2019) state that ADI covers reflective argumentation and a structured peer review process that influences the monitoring strategy.

According to Utami et al. (2022), argument-driven inquiry is a learning model that makes learning active. This model benefits science teachers by helping them get used to learning that can stimulate scientific argumentation skills. Additionally, this learning model facilitates students' stimulation of scientific arguments. However, the ADI model is still rarely used in teaching and learning activities.

Rosidin (2019) discussed in his study why the ADI learning model was effective in enhancing students' critical thinking skills. Through the ADI learning model, students are trained to analyze arguments, starting from identifying conclusions, identifying reasons, looking for similarities and differences, identifying and dealing with irrelevance, searching for structural arguments, and summarizing.

1.3 Scientific Argumentation Skills

According to Samosa (2021), scientific argumentation is an essential practice in science education and serves as fundamental knowledge and skills in scientific inquiry. Students engaging in scientific explanation not only promote their understanding of science but also the nature of science. Since scientific knowledge is an explanation of natural phenomena acquired by scientists using evidence they explored and supporting with scientific reasoning.

Kuki et al. (2023) defined argumentation skills as essential competencies for students to understand science concepts. Additionally, an appropriate learning model is needed to practice argumentation skills. The Argument-Driven Inquiry (ADI) learning model has been widely used to train students' argumentation skills. The ADI model facilitates teachers' design of laboratory-based learning.

Bulgren & Ellis (2015) defined scientific argumentation as a practice present with the following components: 1. identifying a claim as presented in a written document or inquiry activity and analyzing the claim for qualifiers; 2. identifying evidence, labeling the type of evidence, and judging the quality of the evidence; 3. identifying the reasoning that led to the claim, labeling the type of reasoning and judging the quality of the reasoning; 4. presenting rebuttals or counterarguments; and 5. concluding the claim, and explaining the reasoning that supported the conclusion.

According to Grooms et al. (2015), scientific argumentation skill is the process by which science, as a discipline, develops and refines knowledge. When scientists put forth arguments in support of new ideas, the claims, supporting evidence, and rationales or justifications of evidence. Additionally, Argumentation skills become essential competencies for students in understanding science concepts. learning by building arguments trains students to identify several opinions and analyze the truth of opinions rationally and critically (Felton et al., 2015).

According to Parlan et al. (2020), scientific argumentation skill is essential to learning science. There is a link between the ability to argue and academic achievement. Scientific arguments can help increase students' knowledge about concepts, involvement in scientific work, and literacy. The importance of argumentation skills, therefore, necessitates that such practices be encouraged and developed among students in science classroom learning environments (Ping, 2020).

Afandi (2017) emphasizes in his study that argumentation skills are needed in judgments to make decisions, and the skills also include critical thinking skills. Therefore, argumentation skills can be considered part of Higher-Order Thinking Skills (HOTS), which are urgent in 21st-century learning.

According to Rahayu (2023), Scientific argumentation skills are very important to be trained on students in science learning. This is done so students can have a clear view, logical reasoning, and rational explanations regarding the material being studied. Additionally, argumentation skills can equip students to provide explanations related to scientific phenomena that occur in everyday life based on science concepts (Ginanjar & Utari 2015).

Kurniasari & Setyarsih, (2017) found out in their study that scientific argumentation skills have an essential role in science, which is less applied in science programs and activities in the laboratory. Another point is that students hardly practice arguing scientifically in schools with no student-centered system because teaching is focused on the teacher, which represses students' ability to discuss. Moreover, scientific argumentation skill plays a major role in training students to develop their thinking skills to strengthen their knowledge (Devy et al., 2020).

Mao et al. (2018) argue that scientific argumentation is an important competency in scientific inquiry. It is a cognitive skill that tends to be complex, requiring reasoning between theory and evidence and critical thinking. Students' ability to explain scientific phenomena based on evidence/data, theory, and valid reasoning can be reflected in this competency (Rahayu, 2017; Samosa, 2021).

The argumentation skills are highly necessary for scientists and students. Thus, helping students to develop good argumentation skills and supporting students to be able to carefully consider information and reason about situations are critical for preparing students to be able to effectively make decisions about problems in society. Therefore, the promoting argumentation skills in school will be important for driving the progress of science, technology, and society. In the science classroom, educators wish to cultivate students who are knowledgeable in science and who can collaborate effectively (Songsil et al., 2019).

Songsil et al., (2019) also emphasize in their study that scientific argumentation skills play an important part in the science classroom because each student can share their ideas on socio-scientific issues. Moreover, In the context of science education, a scientific argumentation can be seen as a decision based on a scientific proposal or proposition and presents an alternative viewpoint for scientific interpretation (Iordanou & Constantinou, 2015).

1.4 Experiential Learning

Experiential learning is the practical application inspired by the ideals of pragmatism in philosophy applied in education. It is a prominent modern educational theory in the 20th century, associated with names of leading educators such as William James, John Dewey, Jean Piaget, Vygotsky, Lewin, George Santayana and David Kolb. (Giac, 2017).

According to Butler et al. (2019), Experiential Learning is a method of teaching that allows learners to learn while “Do, Reflect, and Think and Apply”. Students take part in a tangible experience (Do), replicate that experience and other evidence (Reflect), cultivate theories in line with experiences and information (Think), and articulate an assumption or elucidate a problem (Apply). Moreover, It is a strong instrument for bringing about positive modifications in academic education, which allows learners to apply what they have learned in school to real-world problems (Guo et al., 2016).

According to Kong (2021), the positive effect of EL has implications for teachers who are considering implementing this method in their classes; indeed, they can guarantee their learners’ success by providing them with the knowledge required to perform the task. Following the experiential theory, knowledge is built by converting practice into understanding.

1.5 Research Objective

This research aimed to enhance Grade 10 students' Scientific Argumentation Skills through Scientific Argument-Driven Inquiry. It sought to understand students' cognition, identify their misconceptions in third-quarter science lessons, and evaluate their experiential exposure through concrete experience, reflective observation, abstract conceptualization, and active experimentation. The study also aimed to assess the effectiveness of argumentative-driven inquiry lesson exemplars in terms of clear learning objectives, building on prior knowledge, engaging opening activities, effective instructional strategies, cohesive closure, and quality assessments. Additionally, it measured the students' pre- and post-performance in scientific argumentation skills, specifically their ability to formulate claims, provide evidence, and reason. The research evaluated whether there was a significant difference in performance before and after utilizing the Argument-driven Inquiry Lesson Exemplar and gathered feedback from students on its use.

2. Methodology

2.1 Research Design

This study used a descriptive-developmental method to determine the association between respondents' scientific argumentation skills and pretest and post-test research design. In descriptive-developmental design, the researcher does not randomly assign the participants because the researcher grouped them according to their section or group where they belonged. Furthermore, the researcher used a rubric, pretest, and post-test to assess the level of argumentation skills of the participants.

This study used a descriptive-developmental research design to design argument-driven inquiry lesson exemplars to improve the respondents' scientific argumentation skills. It also determines whether there is a significant difference between the two groups' levels of scientific argumentative skills before and after using argument-driven inquiry.

2.3 Respondents of the Study

The study respondents were selected purposively. The grade 10 students were composed of 94 students divided into three sections. One section consisted of thirty-one (31) students and was used for pilot testing, while the sixty-three (63) students' respondents in this study were composed of two sections of grade 10 students of Nabangka National High School, Guinayangan, Quezon, enrolled during the school year 2023-2024.

The respondents consist of 38 males and 27 females under the researcher's two sections of grade 10 students. The respondents in each section were divided into six groups to implement the argument-driven inquiry lessons. Each section was given pre-assessment and post-assessment to know the level of scientific argumentation skill of the respondents before and after using the ADI lesson exemplar. The study was conducted during February and March 2024.

2.4 Research Instruments

The instruments used in the input stage in this study to gather data are first is a forty-point multiple-choice examination aligned to the Most Essential Learning Competency (MELCs) of DepEd in the third quarter supported with a researcher-made Table of Specification to determine the learner's cognition, the second is a two-tier True or False test in order to determine the learner's misconceptions in science lessons in the third quarter, the score of the student's respondents were determine with the researcher-made rubric. Third is a survey questionnaire to determine the experiential exposure of the students.

During the process stage, the instruments used were a Lesson Exemplar aligned with argument-driven inquiry and a researcher-made pre-assessment and post-assessment also aligned with the Essential Learning Competency (MELCs) of DepEd to enhance the level of scientific argumentation skills of the students, the score of the students were determined with an adapted rubric. Lastly, the researcher used a researcher-made feedback assessment tool to determine the student's respondents' feedback in the argument-driven inquiry lesson.

To guarantee the accuracy and validity of the instruments, the researcher submitted the research instruments for external and internal validation. A signed letter to the principal and the validators was secured, rubrics for validation were disseminated, and a comments and suggestions sheet was given to the validators. External validators are composed of two (2) Master Teachers specializing in science subjects, one (1) Master teacher majoring in English, Three (3) Teacher III in Science, and two (2) Teacher II also science major. After the instruments were validated, scores to the rubrics were tallied. The validator's comments and suggestions were considered and incorporated in the final copy of the instruments.

2.5 Research Procedure

Implementation: The researcher immediately conducted the research after the validation of the research instruments. The researcher sent a request letter to the Schools Division Superintendent, from the principal of Nabangka National High School, Guinayangan, Quezon, and to the 63 students asking permission to conduct the study by performing a face-to-face discussion using argument-driven inquiry lesson exemplar. The researcher also administered the pilot testing of the research instrument in one of the sections of grade 10 that needs to be included in the respondents to know the validity of and the reliability of the instrument.

The researcher administered the forty (40)-item multiple-choice examination to the sixty-three (63) student's respondents to determine the learner's cognition. The researcher also administers the two-tier True or False test to know the student's misconceptions in science lesson in the third quarter. And lastly the researcher administers the survey questionnaire to measure the student's experiential exposure. All these research instruments are administered before the administration of the face-to-face classes using argument-driven inquiry lesson exemplars.

The researcher administers the researcher-made Pre-assessment tool to the students before the face-to-face administration of the argument-driven inquiry lesson exemplars to determine the level of the students' scientific argumentation skills before the implantation of ADI lessons.

After the students are administered the pre-assessment tool, the researcher starts the argument-driven lessons for the sixty-three (63) students. The respondents are divided into two (2) sections, and each section is divided into six groups; each group is composed of five (5) to six (6) members.

To enhance the level of scientific argumentation of the grade 10 students each of the remaining topics in the third quarter is anchored in the argument-driven inquiry. Each topic is covering one week equivalent to four meetings, one-hour actual teaching time per meeting and another one meeting to accomplish the post-assessment tool in each topic, in total of 5 days each lesson.

After the implementation of the post-assessment tool to the students the researcher carefully assessed and analyzed the results to know if the level scientific argumentation skills of the student increased.

2.6 Data Analysis

After the implementation of the study, pre- and post-assessment were collected and tallied, and give the data to the statistician for treatment. The data were statistically computed, interpreted, and verbally analyzed.

2.7 Ethical Consideration

With outmost confidentiality, the researcher will assure that all the respondent's data, information and the results are accessible only to the researcher and the thesis adviser.

2.8 Statistical Treatment of Data

Frequency and percentage were used to measure the leaner's cognition and misconception. Meanwhile, the mean and standard deviation will be used to calculate the following: 1.) Determining the students' experiential exposure level, 2.) Assessing and validating argument-driven inquiry lesson exemplars, and 3.) Feedback assessment of the students on using ADI lesson exemplars and mean score range will be categorized.

To evaluate respondents' science argumentation skills, the researcher will use an adapted rubric to determine their level of argumentation skills using claim, evidence, and reasoning.

To evaluate the science argumentation skills of the respondents, the mean pre-assessment and post-assessment scores of the respondents will also be determined using the T-Test Difference.

3. Results and Discussion

Table 1. Learners' Cognition Performance

Scores	f	%	Verbal Interpretation
21-40	2	3.2	Mastered
16-20	18	28.6	Move towards mastery
11-15	24	38.1	Average
6-10	19	30.2	Low Mastery
0-5	-	-	No Mastery
TOTAL	**63**	**100.0**	

Table 1 illustrates the cognitive performance of sixty-three (63) Grade 10 students. Most learners fall into the "Average" category, with 24 students (38.1%) scoring between 11-15. A significant portion, 19 learners (30.2%), is in the "Low Mastery" category, scoring between 6-10. There are 18 students (28.6%) who are "Moving towards mastery,"

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with scores ranging from 16-20, and only 2 students (3.2%) have "Mastered" the material, scoring between 21-2. Notably, no learners fall into the "No Mastery" category with scores between 0-5.

The data suggests that while a notable number of students are approaching mastery or have already achieved it, a significant proportion still exhibit average to low levels of cognitive performance. The lack of students in the "No Mastery" category is encouraging, indicating that all students have at least some levels of understanding.

Cognitive performance assessment is crucial for understanding students' learning abilities and academic achievement. A study by Raj (2023) found a significant relationship between the cognitive abilities of high school students and their academic success, highlighting the importance of evaluating these skills to enhance educational outcomes. Similarly, research by Shi (2022) demonstrated that cognitive ability, self-discipline, and planning are significant predictors of academic achievement in high school students, emphasizing the need for comprehensive cognitive assessments to tailor educational strategies effectively.

Moreover, another study by Shi (2021) examined the influence of cognitive abilities and self-control on students' academic performance, revealing a significant positive correlation between self-control abilities and academic success. This underscores the importance of integrating cognitive performance assessments with evaluations of self-discipline and planning to provide a holistic understanding of student's academic capabilities.

Table 2. Misconceptions of the Learners in Science Lessons

Number of Misconception	**f**	**%**	**Verbal Interpretation**
57-75	0	0.00	Very High Misconception
38-56	53	84.13	High Misconception
19-37	10	15.87	Moderate Misconception
0-18	0	0.00	Low Misconception
TOTAL	**63**		

Table 2 shows the scores of Grade 10 students based on a two-tier true or false test to determine their misconceptions in Science lessons in the third quarter. The data reveals that a significant majority of learners, 53 out of 63 (84.13%), have high misconceptions. Additionally, 10 learners (15.87%) exhibit moderate misconceptions, with their scores ranging between 19-37 misconceptions. Notably, there are no learners with very high (57-75 misconceptions) or low (0-18 misconceptions) levels of misconceptions.

The data revealed that the majority of students have a significant number of misconceptions. However, the students have a basic knowledge of the lessons when explaining the concepts behind each topic. Students need help explaining, or they have the wrong idea about the concepts behind each topic in the third quarter. The fact that no students are in the extremely high or low categories indicates that, although misconceptions are common, they are primarily concentrated in the moderate to high range. Additionally, misconceptions can potentially lead to erroneous claims and spread falsity through chains of ill-grounded inferences. Because scientists hold them and precisely work on formulating and justifying knowledge claims, one cannot exclude the possibility of these misconceptions appearing somewhere within the premises of other scientific inferences, thereby leading to other false claims and misconceptions. As a result, internal misconceptions pose a direct threat to knowledge.

Addressing these misconceptions is crucial for improving science education. Research has shown that identifying and correcting misconceptions can significantly enhance students' understanding and retention of scientific concepts. For example, the study by Suprapto (2020) emphasizes the importance of addressing misconceptions to facilitate better learning outcomes and promote a deeper understanding of scientific concepts. Thus, educators must focus on diagnostic assessment tools and targeted instructional strategies to effectively address and reduce misconceptions in science education.

Table 3. Level of Experiential Exposure in terms of Concrete Experience

Statements	Mean	SD	Verbal Interpretation
1. Field Trips	2.43	0.82	Rarely
2. Hands-On Experiments	1.63	0.81	Rarely
3. Live Demonstrations	1.52	0.80	Rarely
4. Outdoor Exploration	1.86	0.88	Rarely
5. Model Building	1.49	0.67	Never
Overall	1.79	0.47	Rarely

Legend: 3.50-4.00 Often, 2.50-3.49 Sometimes, 1.50-2.49 Rarely,1.00-1.49 Never

Table 3 evaluates the level of experiential exposure in terms of concrete experiences for various activities, with the overall mean score of 1.79 falling within the "Rarely" category. This data indicates that students infrequently engage in concrete experiential activities. Such low engagement levels suggest a significant gap in the current educational approaches, emphasizing the necessity for incorporating more hands-on, practical learning opportunities to enhance experiential exposure.

The specific activities evaluated are field trips, hands-on experiments, live demonstrations, outdoor exploration, and model building, which are all critical for fostering the practical knowledge and skills of the students. The scores for each activity consistently fall into the "Rarely" category, except for model building, which falls into the "Never" category. This indicates that students' lack of engagement in practical activities likely hinders students' ability to connect theoretical knowledge with real-world applications.

Experiential learning strategies have been extensively studied and proven to impact students' academic performance and engagement significantly. Research by Kong (2021) emphasizes the role of experiential learning in enhancing students' motivation and application of classroom knowledge. Similarly, a study by Abu-Assab (2015) highlights the positive effect of experiential learning on cognitive skills, social skills, and overall academic performance. These findings underscore the importance of integrating experiential learning strategies into educational practices to improve student's learning outcomes and engagement.

Moreover, studies such as Tan (2021) have demonstrated that learning strategies, including experiential learning, significantly contribute to academic performance. The relationship between experiential learning and academic achievements is further explored in studies like that of Yusof (2020), which focuses on assessing the effectiveness of experiential learning strategies in influencing students' learning experiences. These studies collectively highlight the positive impact of experiential learning on students' cognitive development, motivation, and overall academic achievements, emphasizing the need for educational institutions to prioritize and integrate such strategies into their teaching methodologies.

As discussed by Odden and Kelley (2002), field trips showcase the educational benefits of electronic field trips as interactive learning events, emphasizing real-world experiences and qualitative education. Hands-on experiments, as explored by Darling-Hammond (2020), are essential for practical learning activities, enhancing students' understanding through direct engagement. Live demonstrations, as described in the document from Springer (2017), are crucial as they demonstrate how museums can facilitate learning through interactive exhibits and engaging live demonstrations, offering immersive educational experiences. As discussed by Structural Learning (2023), outdoor exploration plays a vital role in experiential learning, providing valuable opportunities for students to learn in natural environments. Finally, model building, outlined in the PDF from Slideshare (2014), is an integral part of field trips, fostering observational skills and deepening students' understanding of marine life and ecosystems.

Table 4. Level of Experiential Exposure in terms of Abstract Conceptualization

Statements	Mean	SD	Verbal Interpretation
1. Concept Mapping	1.97	0.82	Rarely
2. Mathematical Modeling	1.59	0.69	Rarely
3.Theoretical Analysis	1.51	0.74	Rarely
4. Comparative Studies	1.81	0.80	Rarely
5. Predictive Modeling	1.76	0.89	Rarely
Overall	1.73	0.57	Rarely

Legend: 3.50-4.00 Often, 2.50-3.49 Sometimes, 1.50-2.49 Rarely,1.00-1.49 Never

Table 4 evaluates the level of experiential exposure in terms of abstract conceptualization for various activities, where the computed overall mean score is 1. 73 falls within the "Rarely" category,

To address these findings effectively, educators can draw insights from studies emphasizing active learning strategies like concept mapping and mathematical modeling, which enhance students' understanding of complex concepts and improve critical analysis skills (Tarin, 2024). Additionally, the significance of theoretical analysis and comparative studies in promoting deep learning and critical analysis skills has been well-documented, providing a foundation for designing learning experiences that foster abstract thinking and analytical abilities among students (Koumparaki, 2023). By incorporating these experiential learning methods into teaching practices, educators can create a more engaging and effective learning environment that encourages active exploration of abstract concepts and enhances overall academic performance.

Table 5. Level of Experiential Exposure in terms of Active Experimentation

Statements	Mean	SD	Verbal Interpretation
1. Designing and Conducting Experiments	1.73	0.77	Rarely
2. Building and Testing Models	1.60	0.79	Rarely
3. Investigating Biological Specimens	1.54	0.71	Rarely
4. Analyzing Chemical Reactions	1.67	0.70	Rarely
5. Investigating Force and Motion	1.59	0.69	Rarely
Overall	1.63	0.49	Rarely

Legend: 3.50-4.00 Often, 2.50-3.49 Sometimes, 1.50-2.49 Rarely,1.00-1.49 Never

Table 5 evaluates the level of experiential exposure in terms of active experimentation for various activities, with an overall mean score of 1.63, which falls within the "Rarely" category,

To address the limited experiential exposure identified in the data, educators can draw insights from studies emphasizing the benefits of active experimentation in learning environments (Saber et al., 2015). Hands-on activities such as designing experiments, testing models, and analyzing reactions foster practical skills and enhance students' critical thinking and problem-solving abilities (Nguyen, 2022). Incorporating experiential learning strategies that promote active experimentation can lead to more engaging and effective educational experiences, contributing to comprehensive skill development and improved academic outcomes.

According to Kong (2021), the positive effect of Experiential Learning has implications for teachers who are thinking of implementing this method in their classes; indeed, they can guarantee their learners' success by providing them with the knowledge required to perform the task. According to experiential theory, knowledge is built through converting practice into understanding.

Table 6. Level of Experiential Exposure in terms of Reflective Observation

Statements	Mean	SD	Verbal Interpretation
1. Journaling	1.75	0.90	Rarely
2. Peer Review	1.90	0.86	Rarely
3. Concept Mapping	1.63	0.81	Rarely
4. Comparative Analysis	1.65	0.74	Rarely
5. Feedback Reflection	1.89	0.95	Rarely
Overall	1.77	0.64	Rarely

Legend: 3.50-4.00 Often, 2.50-3.49 Sometimes, 1.50-2.49 Rarely,1.00-1.49 Never

Table 6 evaluates the level of experiential exposure in terms of reflective observation for various activities, with the overall mean score of 1.77 that falls within the "Rarely" category.

Russell's study (2021) emphasizes the effectiveness of experiential learning programs that incorporate reflective observation for producing deeper learning outcomes. Additionally, research on active learning approaches, such as mobile technology-supported experiential learning systems (Wijnen-Meijer, 2022), highlights the benefits of integrating reflective practices to improve students' problem-solving competencies. Therefore, enhancing the level of reflective observation in your educational practices can lead to more comprehensive learning experiences and improved learning outcomes.

Table 7. Assessment of the Lesson Exemplar as to Clear Learning Objectives

Indicators	Mean	SD	Verbal Interpretation
1.The learning objectives appropriately challenging and align with the curriculum standards.	3.75	0.46	Highly Evident
2.The learning objectives able to cover meaningful content, skills, and/or dispositions.	3.75	0.46	Highly Evident
3.There are essential questions to be answered in the lesson.	3.88	0.35	Highly Evident
4.There are most important concepts or skills to be learned.	3.75	0.46	Highly Evident
5. The learning objectives clearly stated in terms of student learning rather than classroom activity or teacher behaviors.	3.88	0.35	Highly Evident
6.The students can understand the learning objectives and they be able to articulate in their own words.	3.75	0.46	Highly Evident
Overall	3.79	0.17	Highly Evident

Legend: 3.50-4.00 Highly evident, 2.50-3.49 Moderately evident,1.50-2.49 Somewhat evident, 1.00-1.49 Not evident

Table 7 evaluates the clarity and effectiveness of learning objectives in an ADI lesson exemplar based on six indicators. Wherein the data shows that the objectives are appropriately challenging and align well with curriculum standards, the learning objectives effectively cover meaningful content, skills, and dispositions, the lesson includes essential questions that need to be answered, the lesson identifies the most important concepts or skills to be learned, the objectives are clearly stated in terms of student learning outcomes rather than classroom activities or teacher behaviors, and Students can understand the objectives and articulate them in their own words.

The data also revealed that the overall mean score is 3.79, which falls within the "Highly Evident" category. This indicates that the ADI lesson exemplar's learning objectives are highly evident, suggesting that they are well-formulated, clear, and effectively communicated to students.

Table 8. Assessment of the Lesson Exemplar as to Building on Prior Knowledge

Indicators	Mean	SD	Verbal Interpretation
1. Students' preconceptions and misconceptions about the subject matter are being addressed	3.75	0.46	Highly Evident
2.The new learning hang on students' prior knowledge and real-world experience	3.88	0.35	Highly Evident
3.There are existing pre-assessment data available to diagnose what students already know/do about the objectives	3.88	0.35	Highly Evident
4. In case of no existing data is available, there are easy and effective pre-assessments created that can analyze quickly, without taking too much instructional time	3.88	0.35	Highly Evident
5.The students' abilities, strengths, and weaknesses, as well as interests, be incorporated into the lesson	3.88	0.35	Highly Evident
Overall	3.85	0.18	Highly Evident

Legend: 3.50-4.00 Highly evident, 2.50-3.49 Moderately evident,1.50-2.49 Somewhat evident, 1.00-1.49 Not evident

Table 8 evaluates the ADI lesson exemplar's effectiveness in building on students' prior knowledge using five indicators. Wherein the data indicates the lesson effectively addresses students' preconceptions and misconceptions about the subject matter, new learning builds strongly on students' existing knowledge and real-world experiences, there is the effective use of pre-assessment data to diagnose students' prior knowledge when no existing data is available, the lesson includes quick and effective pre-assessments without consuming much instructional time, the lesson successfully incorporates students' abilities, strengths, weaknesses, and interests. Additionally, ADI lessons can establish a more active learning atmosphere by inviting learners to participate in the learning process. It is important because investigating science teaching will contribute to science process skill development in a laboratory Demircioglu and Ucar (2015).

The data also reveals the overall mean score of 3.85 which indicates that the lesson exemplar is highly effective in building on students' prior knowledge. This suggests that the lesson is well-designed to address preconceptions, utilize pre-assessments, and incorporate students' abilities and interests.

Table 9. Assessment of the Lesson Exemplar as to Engaging Opening Activity

Indicators	Mean	SD	Verbal Interpretation
1. Activate prior knowledge and relate it to the current lesson	3.88	0.35	Highly Evident
2. Help students see a meaningful need to learn the new information	3.63	0.52	Highly Evident
3.There are some thought-provoking questions to trigger student attention and interest	4.00	0.00	Highly Evident
4.The students show new knowledge and skills that has connections to their personal career or life goals or even how the knowledge and goals fit with their interests today	3.63	0.52	Highly Evident
5. There are specific examples linking the present learning to real world problems	4.00	0.00	Highly Evident
Overall	3.83	0.23	Highly Evident

Legend: 3.50-4.00 Highly evident, 2.50-3.49 Moderately evident,1.50-2.49 Somewhat evident, 1.00-1.49 Not evident

Table 9 evaluates the ADI lesson exemplar's opening activity in terms of its engagement and effectiveness. Where the data reveals that the lesson successfully activates students' prior knowledge and relates it to the current lesson, the lesson helps students see a meaningful need to learn new information, the lesson includes thought-provoking questions that effectively trigger student attention and interest, the lesson allows students to show new knowledge and skills that connect to their personal career or life goals, fitting with their current interests, and the lesson provides specific examples that link the present learning to real-world problems.

The data also reveals that the overall mean score of 3.83 indicates that the ADI lesson exemplars' opening activity is highly effective in engaging students. The indicators suggest that the lesson is well-designed to activate prior knowledge, highlight the importance of new information, provoke student interest, connect to personal goals, and link learning to real-world problems.

Table 10. Assessment of the Lesson Exemplar as to Effective Instructional Strategies

Indicators	Mean	SD	Verbal Interpretation
1. There are the optimal instruction strategies/learning activities for accomplishing the learning objectives, given the resources	3.88	0.35	Highly Evident
2. There is variety of instructional strategies to be used to increase the student engagement and maximize learning	4.00	0.00	Highly Evident
3. The learning materials selected and/or adapted, considering students' age, prior knowledge, and interest	3.88	0.35	Highly Evident
4. The procedures will students need to follow to complete the activities.	4.00	0.00	Highly Evident
5. There is enough time allocated for different parts of the lesson	3.75	0.46	Highly Evident
6. There are potential difficulties that can anticipate by the students	4.00	0.00	Highly Evident
7. The presentation has alternative activity if students have trouble with certain concepts or skills	3.88	0.35	Highly Evident
Overall	3.91	0.13	Highly Evident

Legend: 3.50-4.00 Highly evident, 2.50-3.49 Moderately evident,1.50-2.49 Somewhat evident, 1.00-1.49 Not evident

Table 10 evaluates the effectiveness of ADI lesson exemplars based on various instructional strategies. Where the data reveals that the ADI lesson exemplars use optimal instructional strategies and learning activities to achieve learning objectives given the resources available, the lesson exemplars employ a variety of instructional strategies to increase student engagement and maximize learning, the learning materials are well-selected and adapted, considering students' age, prior knowledge, and interests, the procedures that students need to follow to complete activities are clearly outlined, there is adequate time allocated for different parts of the lesson, the lesson exemplar anticipates potential difficulties that students might face, the presentation includes alternative activities for students who have trouble with certain concepts or skills.

The data also reveals that the overall mean score of 3.91 indicates that the lesson exemplar effectively utilizes instructional strategies. The indicators suggest that the lesson is well-designed to achieve its objectives, engage students, and address potential challenges, ensuring a high-quality educational experience.

Table 11. Assessment of the Lesson Exemplar as to Sticking the Closure

Indicators	Mean	SD	Verbal Interpretation
1. The closure revisits the learning objectives to reinforce and review key concepts, ideas, or principles	3.75	0.46	Highly Evident
2. Theres an active review where students self-assess their understanding or wonder what they would like to know more about	3.88	0.35	Highly Evident
3. The students can draw conclusions, rather than having teachers direct the summarizing	3.88	0.35	Highly Evident
4. Theres an interesting or unexpected prompt at the end to capture students' interest. Or a situation where students might use the new information	3.88	0.35	Highly Evident
Overall	3.84	0.19	Highly Evident

Legend: 3.50-4.00 Highly evident, 2.50-3.49 Moderately evident,1.50-2.49 Somewhat evident, 1.00-1.49 Not evident

Table 11 shows the evaluation of ADI lesson exemplars based on their ability to effectively close a lesson, known as "Sticking the Closure." The data reveals that the closure revisits objectives, reinforcing key concepts, students self-assess understanding or express curiosity, students draw conclusions independently, and a captivating prompt or situation engages students.

The data also reveals that the overall mean score of 3.84 indicates that the ADI lesson exemplars are "Highly Evident" and effectively conclude by revisiting objectives, promoting self-assessment, encouraging independent thinking, and providing engaging prompts. These elements contribute to a cohesive and impactful lesson conclusion, enhancing students' understanding and retention.

Table 12. Assessment of the Lesson Exemplar as to Quality Assessment

Indicators	Mean	SD	Verbal Interpretation
1.The students are making progress toward the objectives	3.88	0.35	Highly Evident
2.The lesson objectives have been accomplished at the end of the lesson	3.88	0.35	Highly Evident
3.The students can produce the expected outcome at the end of the lesson	3.75	0.46	Highly Evident
4.The students' performance is provided feedback	4.00	0.00	Highly Evident
5.The assessment results be communicated to the students	3.88	0.35	Highly Evident
6.The assessment results are used in building the next lesson	3.88	0.35	Highly Evident
Overall	3.87	0.12	Highly Evident

Legend: 3.50-4.00 Highly evident, 2.50-3.49 Moderately evident,1.50-2.49 Somewhat evident, 1.00-1.49 Not evident

Table 12 shows the evaluation of ADI lesson exemplars based on their quality assessment, focusing on various indicators related to student progress, achievement of objectives, feedback provision, and utilization of assessment results.

The data also reveals the overall mean score of 3.87 indicates that the ADI lesson exemplars is "Highly Evident" which reflects a well-designed lesson exemplar that effectively assesses student progress, achieves objectives, provides feedback, communicates results, and uses assessment data for continuous improvement.

Table 13. Pretest and Posttest Performance in Scientific Argumentation Skills

Score	Claim				Evidence				Reasoning				Verbal Interpretation
	Pretest		Posttest		Pretest		Posttest		Pretest		Posttest		
	f	%	f	%	f	%	f	%	f	%	f	%	
26-30	-	-	3	4.8	-	-	2	3.2	-	-	-	-	Excellent
21-25	-	-	29	46.0	-	-	30	47.6	-	-	29	46.0	Above Average
16-20	-	-	31	49.2	-	-	31	49.2	-	-	34	54.0	Average
11-15	14	22.2	-	-	3	4.8	-	-	-	-	-	-	Below Average
6-10	48	76.2	-	-	59	93.7	-	-	47	74.6	-	-	Low
0-5	1	1.6	-	-	1	1.6	-	-	16	25.4	-	-	Very Low
TOTAL	**63**	**100.0**	**63**	**100.0**	**63**	**100.0**	**63**	**100.0**	**63**	**100.0**	**63**	**100.0**	

Legend: 0-5 (Very Low); 6-10 (Low); 11-15 (Below Average); 16-20 (Average); 21-25 (Above Average); 26-30 (Excellent).

Table 13 illustrates students' pretest and posttest performance in scientific argumentation skills as to their Claim, Evidence, and Reasoning. For each component, the pretest scores were predominantly low, with most students scoring between 6-10. Specifically, 76.2% scored in this range for Claims, 93.7% for Evidence, and 74.6% for Reasoning. However, the post-test scores showed significant improvement. For Claims, 49.2% of students scored between 16-20, 46.0% scored between 21-25, and 4.8% reached the highest range of 26-30. Similar improvements were seen in Evidence and Reasoning, with many students moving to higher score ranges.

In the process of using the ADI lesson, students first encounter the “task stage” where the teacher introduces ADI and the topic they need to learn. Students are given tasks related to the given topic. Initially, they struggle to adapt to this new learning model because it is unfamiliar. Still, as the process continues, they become accustomed to it and accomplish the task stage within the given period. The second stage is the “idea stage,” where the teacher provides students with a handout containing core ideas they can use during the investigation. During this stage, researchers observed that most students had positive feedback because they enjoyed learning either independently or with the help of their peers. The third stage, the “plan stage,” involves the students creating, sharing, and revising a plan for collecting and analyzing data using the handout given to them. In this stage, the researcher observed that students could learn how to create plans and analyze data for their investigation. The fourth stage, the “do stage,” is where students implement their plans to collect the data they need and use it to answer the investigation question. By the end of this stage, students have already answered the guiding question. The fifth stage, the “share stage,” is where students create an argument and share it with their peers, critique each other’s work, and then revise the argument based on the feedback they receive from their peers. They create boards where they present the results of their investigation through claims, evidence, and reasoning. Once the boards are created, all groups set up their boards in the classroom and have one or two students stay at the board to present their arguments while other group members rotate around to see what other groups have come up with. While rotating, students write down ways to improve their arguments based on what they see on the other group boards or the feedback from other groups when they visit their boards. Once the gallery walk is finished, students return to their group, and the teacher gives them time to fix up their own board and make any changes before proceeding to the next stage. The next stage is the “reflect stage,” where students discuss ways to use core ideas and practices that they have discovered for future use. During this stage, the teacher facilitates student conversations using images to analyze and guiding questions to synthesize as part of the investigation. The last stage is the “report stage,” where students write up an investigatory report to share with their peers, revise it based on the feedback, and submit it to the teacher.

The findings and the student's experience in the ADI lessons indicate that using the seven stages of Argument-driven lesson exemplars effectively enhanced students' abilities to formulate claims, provide supporting evidence, and construct sound reasoning in scientific contexts.

Table 14. Significant Difference between the pre- and post-assessment of the student's scientific argumentation skills in terms of claim, evidence, and reasoning

	Claim (Post-Pre)	Evidence (Post-pre)	Reasoning (Post-pre)
Z	-6.917[a]	-6.925 [a]	-6.911 [a]
Asymp. Sig. (2-tailed)	.000	.000	.000

Table 14 shows the difference between the pre- and post-assessment of the student's scientific argumentation skills in terms of claim, evidence, and reasoning before and after using the argument-driven inquiry lesson exemplars.

The data shows that the Z-values for the differences in claim, evidence, and reasoning are negative and approximately -6.9. These values indicate the differences between the pretest and posttest scores. The data implies that there is an improvement in the scores from pre- and post-assessment. The Asymp. Sig. (2-tailed) values for the scientific argumentative skills are .000, this indicates that there is a significant difference between the pretest and posttest scores for "Claim," "Evidence," and "Reasoning".

Due to the non-normal distribution of the data, a non-parametric test was used (Wilcoxon) to test the normality of the data. The significant p-values suggest that the intervention significantly improved students' scientific argumentation skills across all three assessed areas (claim, evidence, and reasoning).

Table 15. Feedback Assessment of the Students on the Use of the Argument-Driven Inquiry

Criteria	Mean	SD	Verbal Interpretation
1. The use of argument-driven inquiry lessons helped me understand scientific concepts better.	3.97	0.18	SA
2. The argument-driven inquiry lesson encouraged my curiosity and critical thinking.	3.84	0.37	Strongly Agree
3. I felt engaged and motivated during the lesson using argument-driven inquiry lessons.	3.83	0.38	Strongly Agree
4. The provided materials and instructions were clear and easy to follow.	3.87	0.34	Strongly Agree
5. I enjoyed collaborating with my peers during the investigation.	3.84	0.37	Strongly Agree
6. The lesson enhanced my problem-solving skills.	3.83	0.38	Strongly Agree
7. I felt confident in conducting an investigation and making observations.	3.92	0.27	Strongly Agree
8. The teacher effectively facilitated discussions and guided our learning process.	3.87	0.34	Strongly Agree
9. I believe the lesson prepared me well for future scientific inquiries.	3.83	0.38	Strongly Agree
10. Overall, the Argument-driven Inquiry Lesson was valuable for my learning.	3.87	0.34	Strongly Agree
Overall	3.87	0.14	Strongly Agree

Legend: *3.50-4.00 Strongly Agree, 2.50-3.49 Agree, 1.50-2.49 Disagree, 1.00-1.49 Strongly Disagree*

Table 15 The feedback assessment from students regarding using Argument-Driven Inquiry (ADI) in learning shows overwhelmingly positive responses. With means ranging from 3.83 to 3.97 across various criteria, such as understanding scientific concepts better, encouraging critical thinking, and feeling engaged and motivated during lessons, the students' feedback indicates a strong agreement and satisfaction with the ADI approach. This aligns with studies like the one by Panklin (2023), which highlights ADI's role in enhancing learners' critical thinking and problem-solving skills.

Moreover, the students' positive feedback on the clarity of materials, enjoyment in collaborative activities, confidence in conducting investigations, and belief in ADI's preparation for future scientific inquiries suggests that ADI not only fosters deeper understanding but also promotes a positive learning environment conducive to curiosity, collaboration, and skill development. This resonates with research on experiential learning models like ADI, emphasizing their effectiveness in improving student engagement, motivation, and learning outcomes. Therefore, based on the feedback and related literature, it can be concluded that ADI is a valuable instructional model for enhancing students' learning experiences and outcomes in science education.

Conclusion

Finding of the study showed that there was significant difference between in the pre-assessment and post-assessment performance of the students scientific argumentation skills after the utilization of Argument-driven Inquiry Lesson Exemplar.

References

Acar, Ö., & Patton, B. R. (2016). Examination of learning equity among prospective science teachers who are concrete, formal and postformal reasoners after an argumentation-based inquiry course. Australian Journal of Teacher Education, 41(2), 5 Acting with epistemic agency: Characterizing student critique during argumentation discussions. Science Education, 104(6), 953-982.

Al-Afifi, M., & Ambusaidi, A. (2014). The relationship between the level of investigative skills and logical thinking capabilities among students of the tenth grade in Muscat Governorate/Sultanate of Oman. An-Najah University Journal for Research (Humanities), 11(28), 2522-2556.

Al-Ajm, B., & Ambusaidi, A. (2022). The Level of Scientific Argumentation Skills in Chemistry Subject among Grade 11th Students: The Role of Logical Thinking. Science Education International, 33(1), 66–74. https://doi.org/10.33828/sei.v33.i1.7

Al-Ajmi, B., & Ambusaidi, A. (2019). The Level of Scientific Argumentation Skills in Chemistry. Science Education International, 33(1), 66–74.

Allen, M. (2014). Misconceptions in Primary Science. Mc- Graw-Hill Education (UK).

Andre, L., Durksen, T., & Volman, M. L. (2017). Museums as avenues of learning for children: a decade of research. Learning Environments Research, 20(1), 47–76. https://doi.org/10.1007/s10984-016-9222-9

Antonio, R, & Prudente, M, (2021). Metacognitive Argument-Driven Inquiry in Teaching Antimicrobial Resistance: Effects on Students' Conceptual Understanding and Argumentation Skills

Antonio, R. P., & Prudente, M. S. (2021). Metacognitive Argument-Driven Inquiry in Teaching Antimicrobial Resistance: Effects on Students' Conceptual Understanding and Argumentation Skills. Journal of Turkish Science Education, 18(2), 192–217. https://doi.org/10.36681/tused.2021.60

Anwar, Y., Susanti, R., & Ermayanti. (2019). Analyzing scientific argumentation skills of biology education students in general biology courses. Journal of Physics: Conference Series, 1166(1), 0–5. https://doi.org/10.1088/1742-6596/1166/1/012001

Barrot, J. S., Llenares, I. I., & del Rosario, L. S. (2021). Students' online learning challenges during the pandemic and how they cope with them: The case of the Philippines. Education and Information Technologies, 26(6), 7321–7338. https://doi.org/10.1007/s10639-021-10589-x

Bestiantono, D. S. (2020). Students' Responses toward Scientific Argumentation with ADI Learning Model to Physics Literacy: A Case of Indonesian Senior High School Students. Studies in Learning and Teaching, 1(1), 3–11. https://doi.org/10.46627/silet.v1i1.18

Bizhanova L., Koishigarina A., Pussurmanova G., and Yensepova A., (2021). Developing Argumentation Skills through Reading Strategies in the 8th and 9th Grades

Butler, M. G., Church, K. S., and Spencer, A. W. (2019). Do, reflect, think, apply: experiential education in accounting. J. Acc. Educ. 48, 12–21. doi: 10.1016/j.jaccedu.2019.05.001

Campbell, T., Schwarz, C., & Windschitl, M. (2013). What We Call Misconceptions May Be Necessary Sense of the World. 28–33.

Cassady, Jerrell & Kozlowski, Alison & Kornmann, Mark. (2008). Electronic Field Trips as Interactive Learning Events: Promoting Student Learning at a Distance. Journal of Interactive Learning Research. 19.

Cenk, A. G., & Ercan Yalman, F. (2022). The Observation of Pre-service teachers' argumentation skills on different socioscientific issues. Bartın University Journal of Faculty of Education, 11(1), 31-53. https://doi.org/10.1016/buefad.900562

Cetin, P. S., & Eymur, G. (2017). Developing Students' Scientific Writing and Presentation Skills through Argument Driven Inquiry: An Exploratory Study. Journal of Chemical Education, 94(7), 837–843. https://doi.org/10.1021/acs.jchemed.6b00915

Cetin, P. S., Eymur, G., Southerland, S. A., Walker, J., & Whittington, K. (2018). Exploring the effectiveness of engagement in a broad range of disciplinary practices on learning of Turkish high-school chemistry students. International Journal of Science Education, 40(5), 473-497. 10.1080/09500693.2018.1432914

Cheng, S. C., Hwang, G. J., & Chen, C. H. (2019). From reflective observation to active learning: A mobile experiential learning approach for environmental science education. British Journal of Educational Technology, 50(5), 2251–2270. https://doi.org/10.1111/bjet.12845

Choi, A., Klein, V., & Hershberger, S. (2015). Success, difficulty, and instructional strategy to enact an argument-based inquiry approach: Experiences of elementary teachers. International Journal of Science and Mathematics Education, 13(5), 991- 1011. https://doi.org/10.1007/s10763-014-9525-1.

Chu, S. K. W., Reynolds, R. B., Tavares, N. J., Notari, M., & Lee, C. W. Y. (2021). 21st century skills de- velopment through inquiry-based learning from theo- ry to practice. Springer International Publishing.Cordon, J. M., & Polong, J. D. B. (2020). Behind the Science literacy of Filipino students at PISA 2018: A Case study in the Philippines' Educational System. Integrated Science Education Journal, 1(2), 72–78. https://doi.org/10.37251/isej.v1i2.59

Demirbag, M., & Gunel, M. (2014). Argümantasyon tabanli{dotless} fen eğitimi sürecine modsal betimleme entegrasyonunun akademik başari{dotless}, argüman kurma ve yazma becerilerine etkisi. Kuram ve Uygulamada Egitim Bilimleri, 14(1), 386–391. https://doi.org/10.12738/estp.2014.1.1632

Demircioglu, T., & Ucar, S. (2015). Investigating the effect of argument-driven inquiry in laboratory instruction. Kuram ve Uygulamada Egitim Bilimleri, 15(1), 267–283. https://doi.org/10.12738/estp.2015.1.2324

Demircioglu, T., & Ucar, S. (2015). Investigating the effect of argument-driven inquiry in laboratory instruction. Educational Sciences: Theory & Practice, 15(1).

Deng, Y. & Wang, H. 2017. Research on evaluation of Chinese students' competence in written scientific argumentation in the context of chemistry. Chemistry Education Research and Practice, 18(1):127–150. https://doi.org/10.1039/c6rp00076b.

Devy, H. C., Puspitawati, R. P., & Yakub, P. (2020). Validitas dan Efektivitas LKPD Pendekatan Toulmin's Argument Pattern untuk Melatih Keterampilan Argumentasi. Bioedukasi: Berkala Ilmiah Pendidikan Biologi, 9(1), 80–87.

Dogomeo, J., & Aliazas, J. V. (2022). Dual coding cognition in devising infographics for an enhanced students' scientific knowledge. *International Journal of Science, Technology, Engineering and Mathematics*, *2*(4), 1-17.

Emig, B. R., & McDonald, S. (2014). Inviting argument by analogy: Analogical-mapping-based comparison activities as a scaffold for small-group argumentation. Science Education, 98(2), 243–268.

Erduran, S., Simon, S., & Osborne, J. (2004). TAPping into argumentation: Developments in the application of Toulmin's Argument Pattern for studying science discourse. Science Education, 88(6), 915–933. https://doi.org/10.1002/sce.20012

Erenler, S. & Cetin, P.S. (2019). Utilizing argument-driven-inquiry to develop pre-service teachers' metacognitive awareness and writing skills. International Journal of Research in Education and Science (IJRES), 5 (2), 628-638.

Evagorou, M., Jimenez-Aleixandre, M., & Osborne, J. (2012). Should we kill the grey squirrels? 'A study exploring students' justifications and decision-making. International Journal of Science Education, 34(3), 401–428.

Evidence-Based Argumentive Writing, Journal of the Learning Sciences, 26:4,

Faize, F. A., Husain, W., & Nisar, F. (2017). A critical review of scientific argumentation in science education. Eurasia Journal of Mathematics, Science and Technology Education, 14(1), 475-483.

Faize, F. A., Husain, W., & Nisar, F. (2018). A critical review of scientific argumentation in science education. Eurasia Journal of Mathematics, Science and Technology Education, 14(1), 475–483. https://doi.org/10.12973/ejmste/80353

Faize, F., Husain, W., & Nisar, F. (2018). A critical review of scientific argumentation in science education. Journal of Mathematics, Science and Technology Education, 14(1), 475-483.

Fakhriyah, F., Rusilowati, A., Wiyanto, W., & Susilaningsih, E. (2021). Argument-Driven Inquiry Learning Model: A Systematic Review. International Journal of Research in Education and Science, 767–784. https://doi.org/10.46328/ijres.2001

Felton, M., Garcia-Mila, M., Villarroel, C., & Gilabert, S. (2015). Arguing collaboratively: Argumentative discourse types and their potential for knowledge building. British Journal of Educational Psychology, 85(3), 372–386. https://doi.org/10.1111/bjep.12078

Fitriana, Lesmanawati L I and Maknun D 2014 Penerapan Pembelajaran Berbasis Inquiry Sederhana Untuk Meningkatkan Literasi Sains Siswa Pada Konsep Ekosistem Dikelas X MA Khas Kempek Cirebon J. Tadris. Biologi31 21–34

Frey, B. B., Ellis, J. D., Bulgren, J. A., Hare, J. C., & Ault, M. (2015). Development of a test of scientific argumentation. Electronic Journal for Research in Science & Mathematics Education, 19(4), 1–18.From https://blog.edukasyon.ph/senior-high/the-k- 12-academic-track-series-

Fulton, L., & Poeltler, E. (2013). Modeling and practice help students build skills in oral and written discourse. Science and Children, 50, 30-35.

Gad Allah, W., & Alraqad, H. (2015). Brain control pattern and its relationship to self-organized learning among eighth graders in Amman/ Jordan. An-Najah University Journal for Research, 29(9), 1698-1735.

Giac, C. C., Gai, T. T., Thi, P., & Hoi, T. (2017). Organizing the Experiential Learning Activities in Teaching Science for General Education in Vietnam. World Journal of Chemical Education, 5(5), 180–184. https://doi.org/10.12691/wjce-5-5-7

Ginanjar, W. S., Utari, S., & Muslim. (2015). Penerapan Model Argument- Driven Inquiry dalam Pembelajaran IPA untuk Meningkatkan Kemampuan Argumentasi Ilmiah Siswa SMP. Jurnal Pengajaran MIPA, 20(1), 32–37.

González-Howard, M., & McNeill, K. L. (2020). Acting with epistemic agency: Characterizing student critique during argumentation discussions. Science Education, 104(6), 953-982.

Grooms, J., Enderle, P., & Sampson, V. (2015). Coordinating Scientific Argumentation and the Next Generation Science Standards through Argument Driven Inquiry What Is Scientific Argumentation and Why Is It important in Science?

Gultepe, N., & Kilic, Z. (2015). Effect of scientific argumentation on the development of scientific process skills in the context of teaching chemistry. International Journal of Environmental and Science Education, 10(1), 111–132. https://doi.org/10.12973/ijese.2015.234a

Gultepe, N., & Kilic, Z. (2015). Effect of scientific argumentation on the development of scientific process skills in the context of teaching chemistry. International Journal of Environmental and Science Education, 10(1), 111–132.

Gunawan, G. (2017). Keterampilan Berpikir dalam Pembelajaran Sains. (L. Herayanti, Ed.). Lombok Barat: Penerbit Arga Puji Press.

Guo, F., Yao, M., Wang, C., Yang, W., and Zong, X. (2016). The effects of service learning on student problem solving: the mediating role of classroom engagement. Teach. Psychol. 43, 16–21. doi: 10.1177/0098 628315620064

Hadianto, D., Damaianti, V. S., Mulyati, Y., & Sastromiharjo, A. (2021). Enhancing scientific argumentation skill through partnership comprehensive literacy. Journal of Physics: Conference Series, 2098(1), 0–7. https://doi.org/10.1088/1742-6596/2098/1/012015

Hanifah, N., & Admoko, S. (2019). Penerapan Model Pembelajaran Argument Driven Inquiry (ADI) untuk Melatihkan Kemampuan Argumentasi Ilmiah Peserta Didik SMA. Inovasi Pendidikan Fisika, 08(02), 593–597.

Hariani, N. R., Nuswowati, M., & Winarno, W. (2020). Pengaruh Penerapan Model Inkuiri Terbimbing Berbantuan E-Modul Terhadap Pemahaman Konsep Hidrolisis Garam. Jurnal Inovasi Pendidikan Kimia, 14(1), 2561-2571

Harrison, C. (2014). Assessment of Inquiry Skills in the SAILS Project. Science Education International, 25(1), 112-122.

Hasni, A., Roy, P., & Dumais, N. (2016). The teaching and learning of diffusion and osmosis: What can we learn from analysis of classroom practices? A case study Eurasia Journal of Mathematics, Science & Technology Education, 12(6), 1507–1531. https://doi.org/10.12973/eurasia.2016.1242a

Hasnunidah, N., & Wiono, W. J. (2019). Argument-Driven Inquiry, Gender, and Its Effects on Argumentation Skills. Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah, 4(2), 179–188. https://doi.org/10.24042/tadris.v4i2.4676

Hasnunidah, N., Susilo, H., Henie, M. I., & Sutomo, H. (2015). Argument-driven inquiry with scaffolding as the development strategies of argumentation and critical thinking skills of students in Lampung, Indonesia. American Journal of Educational Research, 3(9), 1195–1192. https://doi.org/10.12691/education-3-9-20

Henderson, J. B., McNeill, K. L., González-Howard, M., Close, K., & Evans, M. (2018). Key Chal- lenges and Future Directions for Educational Research on Scientific Argumentation. Journal of Research in Science Teaching, 55(1), 5-18.

Hilala, R., Laliyo*, L. A. R., Kilo, J. La, Tangio, J. S., Mohamad, E., & Sihaloho, M. (2023). Measuring Students' Scientific Argumentation Skills in Explaining Phenomena Related to Acid-Base Concepts. Jurnal Pendidikan Sains Indonesia, 11(2), 360–378. https://doi.org/10.24815/jpsi.v11i2.27822

Hong, Z.R., Lin, H. shyang, Wang, H.H., Chen, H.T., & Yang, K.K. 2013. Promoting and scaffolding elementary school students' attitudes toward science and argumentation through a science and society intervention. International Journal of Science Education, 35(10):1625–1648. https://doi.org/10.1080/09500693.2012.734935.

Hsu, P., Dyke, M., Smith, T., & Kitlooi, C. (2018). Argue like scientist with technology: the effect of within- gender team argumentation on science knowledge and argumentation skills among middle-level student. Educational Technology Research and Development, 66(3), 733-760.

Huang Ed., R., Xin Ed., B., Tlili Ed., A., Yang Ed., F., Zhang Ed., X., Zhu Ed., L., & Jemni Ed., M. (2022). Science Education in Countries along the Belt & Road: Future Insights and New Requirements. Lecture Notes in Educational Technology. In Lecture Notes in Educational Technology (Issue January). https://doi.org/10.1007/978-981-16-6955-2

Ika Noviyanti, N., Rosyadah Mukti, W., Dahlia Yuliskurniawati, I., Mahanal, S., & Zubaidah, S. (2019). Students' scientific argumentation skills based on differences in academic ability. Journal of Physics: Conference Series, 1241(1), 0–8. https://doi.org/10.1088/1742-6596/1241/1/012034

Iordanou, K., & Constantinou, C. P. (2015). Supporting use of evidence in argumentation through practice in argumentation and reflection in the context of SOCRATES learning environment. Science Education, 99(2), 282–311.

Ismail, N, Alias S, (2006). Inquiry Based Learning: A New Approach To Classroom Learning

Jayson A. Dela Fuente. (2019). Driving Forces of Students' Choice in Specializing Science: A Science Education Context in the Philippines Perspective. The Normal Lights, 13(2), 225–250.

Johanna Mae Traut. (2017). Forming Explanations From Evidence Using the Claim-Evidence-Reasoning Framework. Master's Dessertationfile:///G:/My Drive/Dessertation Proposal/Claim -Evidence Reasoning (Literature)/CER/PichetteC0818.Pdffile:///G:/My Drive/Dessertation Proposal/Claim -Evidence Reasoning (Literature)/CER/PichetteC0818.Pdf, 7(1), 1–10.

Jumadi, J., Perdana, R., Riwayani, & Rosana, D. (2021). The impact of problem-based learning with argument mapping and online laboratory on scientific argumentation skill. International Journal of Evaluation and Research in Education, 10(1), 16–23. https://doi.org/10.11591/ijere.v10i1.20593

KAÇAR, S. (2023). The Effect Of Cognitive Apprenticeship Enriched Argument-Driven Inquiry Method On Pre-Service Teachers' Academic Achievement And Scientific Research Skills. The Universal Academic Research Journal, 5(3), 232–253. https://doi.org/10.55236/tuara.1349197

Kolb, A. Y., and Kolb, D. A. (2017). Experiential learning theory as a guide for experiential educators in higher education. Exp. Learn. Teach. Higher Educ. 1, 7–44.

Kong Y. (2021). The Role of Experiential Learning on Students' Motivation and Classroom Engagement. Frontiers in psychology, 12, 771272. https://doi.org/10.3389/fpsyg.2021.771272

Kong, Y. (2021). The Role of Experiential Learning on Students' Motivation and Classroom Engagement. Frontiers in Psychology, 12(October), 10–13. https://doi.org/10.3389/fpsyg.2021.771272

Kosko, K. W., Rougee, A., & Herbst, P. (2014). What actions do teachers envision when asked to facilitate practice. Journal of Research in Science Teaching, 49(9), 1122–1148. https://doi.org/10.1002/tea.21037

Kuki, A. D., Agustini, R., & Azizah, U. (2023). Analysis of Effectiveness Argument-Driven Inquiry to Improve Students 'Argumentation Skill and Conceptual Understanding. 4(3), 329–342.

Kurniasari, I. S., & Setyarsih, W. (2017). Penerapan model pembelajaran argument driven inquiry (ADI) untuk melatihkan kemampuan argumentasi ilmiah siswa pada materi usaha dan energi. Jurnal Inovasi Pendidikan Fisika (JIPF), 6(3), 171–174.

Kurniasari, S.I. K. A. (2017). Penerapan model pembelajaran argument driven inquiry (ADI) untuk melatihkan kemampuan argumentasi ilmiah siswa pada materi usaha dan energi. Inovasi Pendidikan Fisika, 6(3).

Kurtuluş, M. A., & Tatar, N. (2021). An analysis of scientific articles on science misconceptions: A bibliometric research. Elementary Education Online, 20(1), 192–207. https://doi.org/10.17051/ilkonline.2021.01.022

Lazarou, D., Erduran, S., & Sutherland, R. (2017). Argumentation in science education as an evolving concept: Following the object of activity. Learning, Culture and Social Interaction, 14(2003), 51–66. https://doi.org/10.1016/j.lcsi.2017.05.003

Lentika, D. L., & Admoko, S. (2022). Development of Newton Gravity Student Worksheets on Problem-Based Learning Model to Improve Students' Scientific Argumentation Skills. Prisma Sains : Jurnal Pengkajian Ilmu Dan Pembelajaran Matematika Dan IPA IKIP Mataram, 10(3), 556. https://doi.org/10.33394/j-ps.v10i3.5349

Lestari, H., Rahmawati, I., Siskandar, R., & Dafenta, H. (2021). Implementation of Blended Learning with A STEM Approach to Improve Student Scientific Literacy Skills During The Covid-19 Pandemic. Jurnal Penelitian Pendidikan IPA, 7(2), 224. https://doi.org/10.29303/jppipa.v7i2.654

M., & Lee, C. W. Y. (2021). 21st century skills de-velopment through inquiry-based learning from theo-ry to practice. Springer International Publishing.

Malaterre, C., Javaux, E. J., & López-García, P. (2023). Misconceptions in Science. Perspectives on Science, 31(6), 717–743. https://doi.org/10.1162/posc_a_00590

Mao, L., Liu, O.L., Roohr, K., Belur, V., Mulholland, M., Lee, H.S., & Pallant, A. 2018. Validation of automated scoring for a formative assessment that employs scientific argumentation. Educational Assessment, 23(2):121–138. https://doi.org/10.1080/ 10627197.2018.1427570.

Margus Pedaste, Mario Mäeots, Leo A. Siiman, Ton de Jong, Siswa A.N. van Riesen, Ellen T. Kamp, Constantinos C. Manoli, Zacharias C. Zacharia, Eleftheria Tsourlidaki (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle

Marhamah, O. S., Nurlaelah, I., & Setiawati, I. (2017). Penerapan model argument-driven inquiry (ADI) dalam meningkatkan kemampuan berargumentasi siswa pada konsep pencemaran lingkungan di kelas X SMA Negeri 1 Ciawigebang. Quagga: Jurnal Pendidikan dan Biologi, 9(2), 39-45.

McCright, A.M. (2012). Enhancing students' scientific and quantitative literacies through an inquiry-based learning project on climate change. Journal of the Scholarship of Teaching and Learning, 12(4), 86-102.

McNeill, K. L., Pimentel, D. S., & Strauss, E. G. (2013) The impact of high school science teachers‘ beliefs, curricular enactments and experience on student learning during an inquiry-based urban ecology curriculum. International Journal of Science Education, 35(15), 2608-2644.

Mendonça, P.C.C. & Justi, R. 2014. An instrument for analyzing arguments produced in modeling-based chemistry lessons. Journal of Research in Science Teaching, 51(2):192–218. https://doi.org/10.1002/tea.21133.

Mukrimaa, S. S., Nurdyansyah, Fahyuni, E. F., YULIA CITRA, A., Schulz, N. D., د ,غسان., … Harmianto, S. (2016). No 主観的健康感を中心とした在宅高齢者における 健康関連指標に関する共分散構造分析Title. Jurnal Penelitian Pendidikan Guru Sekolah Dasar, 6(August), 128.

Muntholib, M., Munadhiroh, A., Setiawan, N.C.E., & Yahmin, Y. 2021. High school students' scientific argumentation on chemical equilibrium. AIP Conference Proceedings, 2330. https://doi.org/10.1063/5.0043236.

Nejla Gultepe, Ziya Kilic (2015). Effect of Scientific Argumentation on the Development of Scientific Process Skills in the Context of Teaching Chemistry. International Journal of Environmental & Science Education, 2015, 10(1), 111-132

NGSS Lead States. (2013). Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press.

Nguyen, N. N. (2022). Research on the effect and effectiveness of experiential learning for university students . Journal of Positive School Psychology, 6(8), 4183–4192.

Niki Bagus S, M. W., Admoko, S., & Niki Bagus Wahyune Sukma, M. (2020). Trend To Apply Toulmin Argument Pattern (Tap) To Learning Physics in the Ability To Practice the Argument and Understanding Concepts. 09(02), 276–284.

Noviyani, M., Kusairi, S., & Amin, M. (2017). Penguasaan Konsep dan Kemampuan Berargumentasi Siswa SMP pada Pembelajaran IPA dengan Inkuiri Berbasis Argumen. Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan, 2(7), 974–978.Nussbaum,

OECD (2023), PISA 2022 Results (Volume I): The State of Learning and Equity in Education, PISA, OECD Publishing, Paris, https://doi.org/10.1787/53f23881-en

OECD (2023), PISA 2022 Results (Volume II): Learning During – and From – Disruption, PISA, OECD Publishing, Paris, https://doi.org/10.1787/a97db61c-en

OECD, PISA 2018 Assessment and Analytical Framework, PISA. Paris: OECD Publishing, 2019.

Olusegun, S (2015). Constructivism Learning Theory: A Paradigm for Teaching and Learning

Organisation for Economic Co-operation and Development, (2019). PISA 2018 Results (Volume I): What Students Know and Can Do, PISA, OECD Publishing, Paris, https://doi.org/10.1787/5f07c754-en.

Osborne, J. (2015). Practical work in science: Misunderstood and badly used? School Science Review, 96(357), 16–24.

Osborne, J., Simon, S., Christodoulou, A., Howell-Richardson, C., & Richardson, K. (2013). Learning to argue: A study of four schools and their attempt to develop the use of argumentation as a common instructional practice and its impact on students. Journal of Research in Science Teaching, 50(3), 315-347.

Pacala, F. A., & Cabrales, P. S. (2023). Indonesian Journal Of Education Teaching and Learning (IJETL) SCIENCE EDUCATION IN THE PHILIPPINE COUNTRYSIDE : A PHENOMENOLOGICAL STUDY. 3(1), 12–23.

Panklin, P., & Bongkotphet, T. (2022). ในการค ิ ดอย ่ างม ี ว ิ จารณญาณและการค ิ ดแก ้ ป ั ญหาของน ั กเร ี ยนช ั้ นม ั ธยมศ ึ กษาป ี ท ี่ 5 ปาร ิ ฉ ต ั ร ปานกล ิ่ น * และธ ิ ต ิ ยา บงกชเพร. 17(2).Parlan, P., Latifah, U., & Muntholib, M. (2020). Development and Implementation of Students' Scientific Argumentation Skills Test in Acid-Base Chemistry. Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah, 5(2), 179–190. https://doi.org/10.24042/tadris.v5i2.6388

Patricia Heitmanna, Martin Hechta, Julia Schwanewedelb and Stefan Schipolowskia (2014). Students' Argumentative Writing Skills in Science and First-Language Education: Commonalities and differences. International Journal of Science Education, 2014 Vol. 36, No. 18, 3148–3170, http://dx.doi.org/10.1080/09500693.2014.962644

Pawilen, G. T. (2023). Science Around Us: Development of a Community-based Science Curriculum for Local Preschools in the Philippines. Unnes Science Education Journal, 12(1), 24–31. https://doi.orgPacala, F. A., & Cabrales, P. S. (2023). Indonesian Journal Of Education Teaching and Learning (IJETL) SCIENCE

Ping, I. L. L., & Osman, K. (2019). Laboratory-modified argument driven inquiry (LAB-MADI) module: Content validity process. Jurnal Pendidikan IPA Indonesia, 8(1), 129–140. https://doi.org/10.15294/jpii.v8i1.16867

Ping, I. L. L., Halim, L., & Osman, K. (2020). Explicit teaching of scientific argumentation as an approach in developing argumentation skills, science process skills and biology understanding. Journal of Baltic Science Education, 19(2), 276–288. https://doi.org/10.33225/jbse/20.19.276

PISA. (2016). PISA 2015. [Online]. doi:Available at: www.oecd.org

Purnomo, S., Rahayu, Y. S., & Agustini, R. (2023). Effectiveness of ADI-STEM to Improve Student ' s Science Literacy Skill. 4(5), 632–647.

Pursitasari, I. D., Suhardi, E., Putra, A. P., & Rachman, I. (2020). Enhancement of student's critical thinking skill through science context-based inquiry learning. Jurnal Pendidikan IPA Indonesia, 9(1), 97–105. https://doi.org/10.15294/jpii.v9i1.21884

Rahayu, R., Siswanto, S., Ramadhanti, C. A., & Subali, B. (2023). Guided Inquiry Learning Model Using Scientific Argumentation Activities to Improve Concept Understanding on Optical and Light. Jurnal Pendidikan Fisika Indonesia, 19(1), 55–64. https://doi.org/10.15294/jpfi.v19i1.36626

Rahayu, R., Siswanto, S., Ramadhanti, C. A., & Subali, B. (2023). Guided Inquiry Learning Model Using Scientific Argumentation Activities to Improve Concept Understanding on Optical and Light. Jurnal Pendidikan Fisika Indonesia, 19(1), 55–64. https://doi.org/10.15294/jpfi.v19i1.36626

Rahayu, S. 2017. Promoting the 21st century scientific literacy skills through innovative chemistry instruction. 020025. https://doi.org/10.1063/1.5016018.Rahayu, S. 2019. Socio-scientific Issues (SSI) in chemistry education: Enhancing both students' chemical literacy & transferable skills. Journal of Physics: Conference Series, 1227:012008. https://doi.org/10.1088/1742-6596/1227/1/012008.

Rahmasiwi A, Susilo H and Suwono H 2018 Pengaruh Pembelajaran Diskusi Kelas menggunakan Isu Sosiosains terhadap Literasi Sains Mahasiswa Baru pada Kemampuan Akademik Berbeda Jurnal Pendidikan : Teori, Penelitian dan Pengembangan. 3 8 980–989

Raj, J. A. M., & Komalavalli, S. (2021). An Analysis On Cognitive Ability And Academic Achievement Of High School Students. 17(3), 2441–2445.

Ramadhani, F., & Aprilianingsih, S. (2020). Pengaruh Penerapan Model Pembelajaran Inquiry Terpanduan Terhadap Kemampuan Memahami Konsep Matematika Siswa Kelas VIII MTS Al Islam Petalabumi. Jurnal Matematika Didaktik, 1 (2), 66- 69.

Rauf, R. A. A., Rasul, M. S., Mansor, A. N., Othman, Z., & Lyndon, N. (2013). Inculcation of science process skills in a science classroom. Asian Social Science, 9(8), 47–57. https://doi.org/10.5539/ass.v9n8p47.

Rosidin, U, Kadaritna, N, Hasnunidah, N, (2019). CAN ARGUMENT-DRIVEN INQUIRY MODELS HAVE IMPACT ON CRITICAL THINKING SKILLS FOR STUDENTS WITH DIFFERENTPERSONALITY TYPES?

Rosidin, U., Kadaritna, N., & Hasnunidah, N. (2019). Can argument-driven inquiry models have impact on critical thinking skills for students with differentpersonality types? Cakrawala Pendidikan, 38(3), 511–526. https://doi.org/10.21831/cp.v38i3.24725

Rubini, B., Ardianto, D., Pursitasari, I. D., danPer- mana, I. (2016). Identify scientific literacy from the science teachers' perspective. Jurnal Pendidi- kan

Russell, G., & Hinebaugh, J. (2021). Collegiate Experience : A Literature and Phenomenological Study on Experiential Learning in University Education. November.

Saber, N., & Alkareem, A. (2015). The Effect of Experiential Learning on Improving the Performance of EFL Students as Perceived by Teachers of English in the Northern Governorates of Palestine. 109. https://scholar.najah.edu/sites/default/files/Noor Saber Abd Alkareem Abu-Assab.pdf

Samosa, R.C. 2021. Effectiveness of claim, evidence and reasoning as an innovation to develop students' scientific argumentative writing skills. Journal of Multidimensional Research & Review, 2(1):2708–2752.

Sampson, V., & Blanchard, M. R. (2012). Science teachers and scientific argumentation: Trends in views and practice. Journal of Research in Science Teaching, 49(9), 1122–1148. https://doi.org/10.1002/tea.21037

Sampson, V., Carafano, P., Enderle, P., Fannin, S., Grooms, J., Southerland, S. A., … Williams, K. (2015). Argument-Driven Inquiry in.

Sampson, V., Enderle, P., Grooms, J., & Witte, S. (2013). Writing to learn by learning to write during the school science laboratory: Helping middle and high school students develop argumentative writing skills as they learn core ideas. Science Education, 97(5), 643–670. https://doi.org/10.1002/sce.21069

Sari, M. P. (2023). IMPLEMENTATION OF ARGUMENT-DRIVEN INQUIRY (ADI) LEARNING MODELS ON ENVIRONMENTAL POLUTION TOPIC TO ENHANCE SEVENTH GRADE STUDENTS ' LEARNING OUTCOMES, 5(1), 12–19.

Saweknngam, W. (2014). The reasoning ability, the ability needs for students in the 21st century. Journal of Education Studies,42(2), 207–223.

Sekerci, A. R., & Canpolat, N. (2017). Argumentation skills of Turkish freshman university students in chemistry laboratory. Journal of Educational Sciences and Psychology, VII(1), 26–39.

Sharma, G. (2017). Pros and cons of different sampling techniques, international journal of applied research, 3(7), 749-752.

Shi YQ and Qu SW (2021) Cognitive Ability and Self-Control's Influence on High School Students' Comprehensive Academic Performance. Front. Psychol. 12:783673. doi: 10.3389/fpsyg.2021.783673

Shi, Y., & Qu, S. (2022). The effect of cognitive ability on academic achievement: The mediating role of self-discipline and the moderating role of planning. Frontiers in psychology, 13, 1014655. https://doi.org/10.3389/fpsyg.2022.1014655

Shin, N., Choi, S.Y., Stevens, S.Y., & Krajcik, J.S. 2019. The impact of using coherent curriculum on students' understanding of core ideas in chemistry. International Journal of Science and Mathematics Education,

Siswanto, S., Kaniawati, I., & Suhandi, A. (2014). Penerapan Model Pembelajaran Pembangkit Argumen Menggunakan Metode Saintifik UntukMeningkatkanKemampuan Kognitif danKeterampilan Berargumentasi Siswa. Indonesian Journal of Physics Education, 10(2), 104-116.

Soeharto, Csapó, B., Sarimanah, E., Dewi, F. I., & Sabri, T. (2019). A review of students' common misconceptions in science and their diagnostic assessment tools. Jurnal Pendidikan IPA Indonesia, 8(2), 247–266. https://doi.org/10.15294/jpii.v8i2.18649

Songsil et al. (2019). Developing scientific argumentation strategies using revised argument-driven inquiry (rADI) in science classrooms in Thailand

Songsil, W., Pongsophon, P., Boonsoong, B., & Clarke, A. (2019). Developing scientific argumentation strategies using revised argument-driven inquiry (rADI) in science classrooms in Thailand. Asia-Pacific Science Education, 5(1), 1–22. https://doi.org/10.1186/s41029-019-0035-x

Srougi, M.C., Thomas – Swanik,J., Chan, J.D., Marchant, J.S. & Carson, S. (2014). Making Heads of Tails: Planarian Stem Cells in the Classroom. Journal of Microbiology and Biology Education. 15(1), 18-25.stem/

Students, M. S. (2020). 13176-Article Text-38018-1-10-20200715(1).pdf. 19.

Subayani, N. W. (2016). The Profile of Misconceptions among Science Subject Student-Teachers in Primary Schools. International Journal of Education and Literacy Studies, 4(2). https://doi.org/10.7575/aiac.ijels.v.4n.2p.54

Sukardi, R. R., & Agustrianti, Y. V. (2017). Analysis of Students' Argumentation Skill and Conceptual Knowledge in Friction Force Lesson through Argumentative Task, 57(ICMSEd 2016), 80–84. https://doi.org/10.2991/icmsed-16.2017.18

Suprapto, N. (2020). Do We Experience Misconceptions?: An Ontological Review of Misconceptions in Science. Studies in Philosophy of Science and Education, 1(2), 50-55. https://doi.org/10.46627/sipose.v1i2.24

Surpless B, Bushey M, Halx M, Surpless B, Bushey M and Halx M 2018 Developing Scientific Literacy in Introductory Laboratory Courses : A Model for Course Design and Assessment J. Geo. Educ.62 2 244-263

Talanquer, V. 2018. Progressions in reasoning about structure-property relationships. Chemistry Education Research and Practice, 19(4):998–1009. https://doi.org/ 10.1039/c7rp00187h.

Tan, S.F., Din Eak, A., Ooi, L.H. and Abdullah, A.C. (2021), "Relationship between learning strategies and academic performance: a comparison between accreditation of prior experiential learning (APEL) and regular entry undergraduates", Asian Association of Open Universities Journal, Vol. 16 No. 2, pp. 226-238. https://doi.org/10.1108/AAOUJ-08-2021-0081

Tanya Hobbs Long (2014). Effects of The Claims-Evidence-Reasoning Writing Framework

Testa, I., Capasso, G., Colantonio, A., Galano, S., Marzoli, I., Scotti di Uccio, U., Trani, F., & Zappia, A. 2019. Development and validation of a university students' progression in learning quantum mechanics through exploratory factor analysis and Rasch analysis. International Journal of Science Education, 41(3):388–417. https://doi.org/ 10.1080/09500693.2018.1556414.

Tümay, H. 2016. Emergence, learning difficulties, and misconceptions in chemistry undergraduate students' conceptualizations of acid strength. Science and Education, 25(1–2):21–46. https://doi.org/10.1007/s11191-015-9799-x.

Turiman, P., Omar, J., Daud, A. M., & Osman, K. (2012). Fostering the 21st century skills through scientific literacy and science process skills. Pro- cedia-Social and Behavioral Sciences, 59, 110-116.

Type, T., Doi, U. R. L., Citation, D., Education, S., It, C. C., Rights, I. P., & Rights, M. (2015). Central Lancashire Online Knowledge (CLoK) Supporting Use of Evidence in Argumentation through Practice in Argumentation and Reflection University of Cyprus , Cyprus.

Type, T., Doi, U. R. L., Citation, D., Education, S., It, C. C., Rights, I. P., & Rights, M. (2015). Central Lancashire Online Knowledge (CLoK) Supporting Use of Evidence in Argumentation through Practice in Argumentation and Reflection University of Cyprus , Cyprus.

Utami, S. S., Sari, R., Aisyah, S., & Affifah, I. (2022). Application of the argument-driven inquiry learning model in stimulating students ' scientific argumentation skills on acid-base material. Jurnal Pendidikan Kimia Indonesia, 6(1), 38–45. https://doi.org/10.23887/jpk.v6i1.39162

Viyanti, V., Cari, C., Sunarno, W., & Prasetyo, Z. K. (2016). Pemberdayaan keterampilan argumentasi mendorong pemahaman konsep siswa. Jurnal Penelitian Pembelajaran Fisika, 7(1), 43-48. Wisudawati,

Walker, J, Sampson, V, Grooms, J, Anderson, B, Zimmerman, C, (2016). Argument-Driven Inquiry in Undergraduate Chemistry Labs: The Impact on Students' Conceptual Understanding, Argument Skills, and Attitudes Toward Science

Walker, J. P., Sampson, V., Grooms, J., Anderson, B., & Zimmerman, C. O. (2011). Argument-Driven Inquiry in Undergraduate Chemistry Labs: The Impact on Students' Conceptual Understanding, Argument Skills, and Attitudes Toward Science. Journal of College Science Teaching, 41(4), 74–81.

Wang Y, Lavonen J, Tirri K, and Wang Y 2019 An assessment of how scientific literacy-related aims are actualised in the National Primary Science curricula in China and Finland In. J. Sci. Educ.41 111435-1456

Wijayanti A and Basyar M A K 2016The DevelopmentOf Thematic-Integrated E-Portfolio Media Web Blog Based To Increase The Scientific Literacy Of Elementary Teacher Education Program'S Student2016 Jurnal Pendidikan IPA Indonesia. 52 284–290

Wikara, B., Sutarno, S., Suranto, S., & Sajidan, S. (2022). Implementation of 5E Plus Learning Model on Energy Subject Matter To Improve Students' Argumentation Skills. Jurnal Pendidikan IPA Indonesia, 11(2), 237–245. https://doi.org/10.15294/jpii.v11i2.30567

Yu, N. (2018). The K-12 Academic Track Series:STEM retrieved

Yusof, R., Yin, K. Y., Norwani, N. M., Ismail, Z., Ahmad, A. S., & Salleh, S. (2020). Teaching through experiential learning cycle to enhance student engagement in principles of accounting. International Journal of Learning, Teaching and Educational Research, 19(10), 323–337. https://doi.org/10.26803/IJLTER.19.10.18

Zeidler, D. L., & Sadler, T. D. (2008). Social and ethical issues in science education: A prelude to action. Science & Education, 17(8), 799-803. https://doi.org/10.1007/s11191-007-9130-6.

Микрюков, В. (2015). No Тяжелое бремя АмерикиTitle. Независимое Военное Обозрение, (16.1.2015).