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Socio-Scientific Issue-Based Instruction in Enhancing Informed Decision-Making of Grade 9 Students

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ABSTRACT

In an era defined by the convergence of rapidly advancing science and ever-evolving societal issues, the ability to make informed, ethical, and effective decisions has become more crucial than ever before. This study aimed to compare the effects of socio-scientific issue-based instruction integrated into argument-based learning and scenario-based learning in the informed decision-making skills of Grade 9 students. The two-group posttest-only experimental research design was employed in this study. Two sections from Grade 9 in San Pablo City Integrated High School (SPCIHS) comprised the experimental groups. Both groups included forty (40) learners who were purposely selected. The posttest instrument utilized was made up of a thirty (30)-item test to measure students' informed decision-making skills in terms of informal reasoning, evidence-based reasoning, and social interaction which were drawn from the 3rd quarter of the Earth Science (Volcano and Climate) topics for Grade 9 Science. Comparative analysis confirmed that argument-based learning is more effective overall in enhancing informed decision-making skills. This approach's structured and interactive nature contributed significantly to the higher proficiency levels observed in the respondents, making it a superior method for developing critical thinking, reasoning, and collaborative abilities. Therefore, it was concluded that there is a significant difference between the posttest scores of the respondents in Argument-based learning and Scenario-based learning in terms of informal reasoning and social interaction. Thus, it is suggested that structured analytical frameworks should be developed to guide students through argument construction and evaluation systematically.

Keywords: Socio-scientific Issues, Argument-based, Scenario-based, Informed Decision-making

INTRODUCTION

The challenge for the modern educational system is to equip students with the skills they will need to survive in a world where scientific and technical developments are fundamental to determining how people live their daily lives. This calls for fostering not only a fundamental comprehension of scientific principles but also the capacity to apply them in practical contexts, weigh informed decision-making's potential effects, and actively engage in discussions that cover ethical, societal, and environmental issues. In an era defined by the convergence of rapidly advancing science and ever-evolving societal issues, the ability to make informed, ethical, and effective decisions has become more crucial than ever before. Nowhere is this significance more pronounced than in the lives of students, who are on the cusp of adolescence and academic maturity. As these students stand at the crossroads of their educational journey, they are confronted with a multitude of socio-scientific challenges that demand careful consideration and informed choices. Scientific literacy is known to encompass informed decision-making, which includes processing scientific knowledge, applying scientific content knowledge to problem-solving, and cultivating critical thinking skills. Furthermore, the ultimate objective of science education has been described as scientific literacy. Science-literate people should be able to study, question, make wise decisions, recognize issues in their environment, and come up with solutions. These adjustments can occasionally cause issues. Raising people who approach these societal issues from a scientific perspective is crucial, for this reason. The innovations that enter our lives as a result of changing and developing technologies are addressed by socio-scientific issues (SSI), which are included in the science curriculum. The contents are set up to allow students to investigate these issues using their knowledge of the scientific method and to come up with solutions to the problems that arise. Unfortunately, current trends show that many learners lack these essential abilities.

As we enter the digital era, the difficulties in making well-informed decisions are intensified. The proliferation of the information age has inundated individuals with an overwhelming amount of data, posing difficulties in distinguishing pertinent and trustworthy information amidst the overwhelming volume of irrelevant information. Pennycook et al. (2018) conducted a study that revealed that a considerable segment of the public tends to accept and propagate false information. This highlights the necessity for enhanced proficiency in making informed decisions, particularly in the current age of false news and excessive information.

Despite the undeniable importance of informed decision-making, a pressing problem persists among students. Many of them encounter formidable challenges when confronted with the intricate web of socio-scientific issues. They often find it difficult to assess evidence critically, analyze information systematically, and engage in constructive discourse to arrive at well-informed decisions. This deficiency in informed decision-making skills is a

significant concern, as it not only affects their academic progress but also compromises their future roles as active, responsible citizens capable of addressing pressing societal challenges.

The significance of informed decision-making is emphasized by numerous research. An example of this is a study conducted by Dunning and Kruger which uncovered a cognitive bias where persons with limited proficiency in a task tend to overestimate their aptitude. The Dunning-Kruger effect highlights the need for individuals to acknowledge their limits and actively seek knowledge before making judgments. Stanovich and West (2018) contended in their study that informed decision-making necessitates more than mere intellect. It entails the amalgamation of critical thinking abilities and the capacity to surmount cognitive biases.

LITERATURE REVIEW

Science education has a vital role to play in preparing future citizens. It's not just about imparting knowledge of scientific concepts; it's about equipping students with the tools to navigate the complexities of the real world (Osborne & Dillon, 2008). Here, socio-scientific issues (SSIs) emerge as powerful tools for learning. SSIs are real-world challenges that bridge the gap between science and societal concerns, prompting students to grapple with the scientific underpinnings and ethical dilemmas associated with these issues (Subiantoro, 2017). However, implementing SSI effectively can be challenging. Teachers may face constraints in student proficiency, their own expertise, and curriculum demands (Nida et al., 2020).

Despite these challenges, research paints a promising picture. When combined with argument-based learning (ABL), SSI can foster a deep understanding of scientific concepts, ethical considerations, and critical argumentation skills—all crucial for informed decision-making (Choi et al., 2014; Chin et al., 2015; Capkinoglu & Yilmaz, 2019). Through ABL, students actively engage with SSIs, analyzing evidence and constructing solutions to these complex problems (Smith et al., 2016; Schenk et al., 2019). This equips them to approach real-world issues with a foundation of scientific knowledge and sound reasoning, enabling them to make informed choices as engaged citizens (Khishfe, 2018; Zeidler & Nichols, 2019).

At the heart of successful SSI lies scientific inquiry, a process where students formulate hypotheses and gather evidence to test them (Gultepe & Kılıç, 2015). ABL complements this process by encouraging students to develop solutions for SSIs and defend their arguments with evidence (Dawson & Venville, 2020). Through scientific argumentation, students learn to construct, defend, and critique arguments based on data, not just opinion. This focus on evidence-based reasoning strengthens their grasp of scientific concepts and prepares them to make informed decisions in various contexts (Evagorou & Osborne, 2016; Songsil, 2019; Ural, 2020).

The benefits of argumentation extend beyond content knowledge. Argumentation activities, when designed effectively, can enhance critical thinking, logical reasoning, and focus on relevant subject matter. This ultimately leads to deeper learning experiences (Mercan, 2017). Studies have shown that ABL can cultivate a deeper understanding of scientific topics, improve problem-solving skills, and encourage students to consider multiple perspectives, ultimately refining their own arguments (Ozelma & Seyhan, 2022; Introne, 2014).

Scenario-based learning (SBL) adds another critical layer to this framework. By placing students in simulated real-world contexts that mirror SSIs, SBL allows them to apply their knowledge and hone critical skills (Elliot-Kingston & Hunter, 2016; Lloyd & Neo, 2020). Engaging with these scenarios fosters collaborative work, problem-solving abilities, and the development of a diagnostic and research-oriented mindset (Markovic, 2023; Singhai, 2017). This, in turn, builds confidence in their decision-making abilities, a crucial skill for navigating the complexities of an information-rich world.

Integrating ABL, and SBL to SSI offers a powerful approach for empowering grade 9 students to become informed decision-makers. By equipping students with the necessary skills and knowledge to analyze evidence, construct arguments, and apply their understanding to real-world problems, we cultivate a generation of scientifically literate citizens who can actively participate in a democratic society and make informed choices on the complex scientific issues that will shape their future.

METHODOLOGY

This study employed a two-group posttest-only experimental research design. The two-group design, according to Calmorin (2010), uses two comparable groups as experimental groups, or two groups that are both experimental. According to Sung et al. (2017), the two-group posttest-only research design is used to compare the effects of intervention on the respondents. Two sections from Grade 9 in San Pablo City Integrated High School (SPCIHS) comprised the experimental groups. Both groups included forty (40) learners who were purposely selected. The selected groups were considered regular sections of grade 9 level heterogeneously organized and at the same level in terms of prior knowledge. The instruments employed in this study include a researcher-made posttest for argument-based and scenario-based learning. The posttest instrument was made up of a thirty (30)-item test to measure students' informed decision-making skills in terms of informal reasoning, evidence-based reasoning, and social interaction which were drawn from the 3rd quarter of the Earth Science (Volcano and Climate) topics for Grade 9 Science. The respondents' scores and the groups' scores after the treatment were compared using the t-test of difference to assess whether there would be a significant difference at the 0.05 level of significance.

RESULTS AND DISCUSSION

Table 1

Post-test scores in Informed Decision-Making Skills Assessment of the Respondents Exposed to Socio-scientific Issue-Based Instruction in terms of Informal Reasoning

Scores	Scenario-Based Learning								Argumentation-based Learning								Verbal Interpretation
	Week 1		Week 2		Week 3		Week 4		Week 1		Week 2		Week 3		Week 4		
	f	%	f	%	f	%	f	%	F	%	f	%	f	%	f	%	
14-16	19	47.5	24	60	31	77.5	37	92.5	28	70	34	85	36	90	38	95	Highly Proficient
11-13	21	52.5	16	40	9	22.5	3	7.5	12	30	6	15	4	10	2	5	Proficient
8-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Nearly Proficient
5-7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Low Proficient
4 & below	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Not Proficient
Total	40	100	40	100	40	100	40	100	40	100	40	100	40	100	40	100	

Interpretation: *Highly Proficient (14-16); Proficient (11-13); Nearly Proficient (8-10); Low Proficient (5-7); Not Proficient (0-4)/ Highly Proficient (17-20); Proficient (13-16); Nearly Proficient (9-12); Low Proficient (5-8); Not Proficient (0-4)*

Table 1 provides the post-test scores in the Informed Decision-Making Skills Assessment for respondents exposed to socio-scientific issue-based instruction, focusing on informal reasoning.

The improvement observed in students' scores over the 4 weeks can be attributed to scenario-based learning, which involves engaging students in realistic and complex scenarios that require applying their reasoning skills to real-world problems. This immersive and contextualized learning experience can enhance students' ability to apply their knowledge and skills effectively, leading to higher proficiency levels.

During the study, learners were more engaged in reasoning when presented with different situations related to their daily lives. For instance, learners were tasked to substantiate existing superstitions related to a volcanic eruption. The learners conducted in-depth interviews with their relatives about this community's beliefs such as "if you are pregnant, you need to take a bath after the earthquake or else the baby might be miscarriage". In this activity in week 2, learners were exposed to the situations and perceptions in the community that led them to decide for themselves whether the superstition was acceptable or not. Scenario-based learning immerses learners in real-world or simulated situations, or scenarios. These scenarios are designed to reflect authentic challenges or dilemmas relevant to the subject matter being taught. This immersive and contextualized learning experience can enhance students' ability to effectively apply their knowledge and skills, leading to higher proficiency levels.

Research supports the effectiveness of scenario-based learning. For instance, a study by Bennett et al. (2015) demonstrated that students who engaged with realistic scenarios significantly improved their problem-solving and decision-making skills. Similarly, Evagorou and Dillon (2016) found that scenario-based learning helps students understand the complexities of socio-scientific issues and apply their reasoning skills in meaningful contexts.

On the other hand, students exposed to argumentation-based learning also showed notable improvements in their informal reasoning skills in the 4-week implementation of the study. In Week 1, 70% of students were categorized as Highly Proficient, which increased to 85%, 90%, and 95% in Weeks 2 to 4 respectively. The percentage of students classified as Proficient correspondingly decreased from weeks 1 to 4 from 30% to 15%, 10%, and 5%.

In the implementation of the study, it was observed that as the learners were exposed to argument-based learning, they became better at informal reasoning in four weeks. For example, in week 2, the students were given information about the Taal volcanic eruption from the firsthand experiences of the people in the barangay, and they were tasked to create a well-structured argument and plan that could be presented in their local barangays during a volcanic eruption. This prompted the learners to reason out and defend their stand and plan to the authorities of the barangay based only on the non-formal information of the community. The high proficiency level observed in students' scores can be attributed to the nature of argument-based learning, which emphasizes the development of critical thinking and reasoning through constructing and critiquing existing beliefs and experiences, and how could this be used as a basis to create new plans or ideas. This approach helps students to structure their thoughts systematically and present coherent arguments, which likely contributes to the steady increase in their proficiency levels.

These results were supported by the study of Sampson and Clark (2014) stating that argument-based learning enhances students' ability to engage in scientific reasoning and argumentation. This instructional method encourages students to evaluate evidence, consider multiple perspectives, and construct well-reasoned arguments, leading to improved decision-making skills. The significant gains observed in this study align with the broader literature indicating the effectiveness of argument-based learning in promoting higher-order thinking skills (Osborne, 2014; Simon, 2016).

Table 2

Post-test scores in Informed Decision-Making Skills Assessment of the Respondents Exposed to Socio-scientific Issue-Based Instruction in terms of Evidence-based Reasoning

Scores	Scenario-based Learning								Argument-Based Learning								Verbal Interpretation
	Week 1		Week 2		Week 3		Week 4		Week 1		Week 2		Week 3		Week 4		
	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%	
14-16	24	60	33	82.5	36	90	36	90	27	67.5	33	82.5	38	95	36	90	Highly Proficient
11-13	16	40	7	17.5	4	10	4	10	13	32.5	7	17.5	2	5	4	10	Proficient
8-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Nearly Proficient
5-7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Low Proficient
4 & below	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Not Proficient
Total	40	100	40	100	40	100	40	100	40	100	40	100	40	100	40	100	

Interpretation: *Highly Proficient (14-16); Proficient (11-13); Nearly Proficient (8-10); Low Proficient (5-7); Not Proficient (0-4)/ Highly Proficient (17-20); Proficient (13-16); Nearly Proficient (9-12); Low Proficient (5-8); Not Proficient (0-4)*

Table 2 depicts the post-test scores for the Informed Decision-Making Skills Assessment of respondents exposed to socio-scientific issue-based instruction in terms of evidence-based reasoning, showing a marked improvement in proficiency over four weeks.

In the Scenario-based Learning approach, there is a clear progression in the percentage of respondents achieving "Highly Proficient" scores (14-16). Initially, 60% of the respondents were categorized as highly proficient in week 1. This percentage increases to 82.5%, 90%, and 90% in weeks 2 to 4 respectively. This upward trend indicates that the SBL approach effectively enhances evidence-based reasoning skills over time. Additionally, the proportion of respondents classified as "Proficient" (scores 11-13) decreases from 40% in week 1 to 10% by week 4. This decline corresponds with the increase in the highly proficient category, suggesting that more respondents transition from proficient to highly proficient as the instruction progresses. Notably, no respondents fall into the "Nearly Proficient" (8-10), "Low Proficient" (5-7), or "Not Proficient" (0-4) categories throughout the four weeks.

These results can be attributed to the activities given in the scenario-based context. For instance, learners tend to be more careful in accepting or rejecting pieces of evidence during the activity that might lead them to improve their decision-making skills. In week 4, for example, the teacher provided the learners with evidence of climate change in the Philippines. The students were exposed to different environmental problems attributed to climate change such as drought, flood, extreme heat indices, and increased rates of diseases. In this activity, learners were tasked to prepare a simple infographic about the effects of climate change to be discussed to random students in the school. Through this, learners became more proficient in reasoning skills using empirical data presented by their teacher. Moreover, scenario-based learning can be tailored to different contexts and disciplines, making it a versatile tool for educators. By presenting students with scenarios that are relevant to their interests and community problems, educators can increase motivation and the perceived value of the learning activity. This relevance helps students see the connection between their studies and real-world applications, further enhancing their engagement and the effectiveness of the learning process.

These findings align with the literature, Greene et al. (2018) have demonstrated that scenario-based learning environments provide authentic contexts that significantly improve learners' critical thinking and problem-solving skills. Similarly, Darling-Hammond et al. (2020) noted that scenario-based learning enhances student engagement and understanding by placing them in realistic situations requiring the application of learned concepts.

In terms of the Argument-Based Learning approach, the result also shows a high proficiency level in the respondents' evidence-based reasoning skills. In week 1, 67.5% of respondents were highly proficient, which increases to 82.5% in week 2, and peaks at 95% in week 3. Although there is a slight decline to 90% in week 4, the overall trend remains positive and comparable to the SBL approach. Similar to the SBL approach, the percentage of proficient respondents in the ABL group decreases over time, dropping from 32.5% in week 1 to 10% by week 4. This transition from proficient to highly proficient indicates the effectiveness of the ABL approach in enhancing evidence-based reasoning during the implementation of the study. As with the SBL group, no respondents fall into the lower proficiency categories throughout the four weeks.

During the debates and arguments, learners become more focused on the details presented by other groups. Each group keenly scrutinizes the data or evidence of their classmates, thus, having a more solid stand in the case, especially during rebuttal. For instance, in week 2 learners were tasked to evaluate documents such as newspapers and magazines, and video clips about the Taal eruption. In this activity, the students interact with each other to accept or reject evidence of volcanic phenomena. This involves assessing signs of looming volcanic eruptions such as frequent earthquakes, fissures, and steam production. Learners reason out to each other in the FGD to come up with acceptable reasoning and discussion as to why they accept or reject the evidence of volcanic eruption to be presented in the class. In this activity, learners were exposed to a very high level of scrutiny within the group. It was observed that each student brought out different angles of the issue. After the group activity, learners conducted a presentation of their output to be scrutinized again by the whole class.

These observations are supported by recent studies, for example, Kuhn and Moore (2015) highlighted that argumentation-based learning enhances students' ability to reason scientifically and make informed decisions. Similarly, Noroozi et al. (2016) found that engaging students in structured argumentation significantly improves their critical thinking and reasoning skills.

Table 3

Post-test scores in Informed Decision-Making Skills Assessment of the Respondents Exposed to Socio-scientific Issue-Based Instruction in terms of Social Interaction

| Scores | Scenario-based Learning | | | | | | | | Argument-Based Learning | | | | | | | | Verbal Interpretation |
| | Week 1 | | Week 2 | | Week 3 | | Week 4 | | Week 1 | | Week 2 | | Week 3 | | Week 4 | | |
	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%	
17-20	30	75	40	100	30	75	40	100	40	100	40	100	40	100	40	100	Highly Proficient
13-16	10	25	0	0	10	25	0	0	0	0	0	0	0	0	0	0	Proficient
9-12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Nearly Proficient
5-8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Low Proficient
4 & below	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Not Proficient
Total		100	40	100	40	100	40	100	40	100	40	100	40	100	40	100	

Interpretation: *Highly Proficient (14-16); Proficient (11-13); Nearly Proficient (8-10); Low Proficient (5-7); Not Proficient (0-4)/ Highly Proficient (17-20); Proficient (13-16); Nearly Proficient (9-12); Low Proficient (5-8); Not Proficient (0-4)*

Table 3 illustrates the post-test scores for the Informed Decision-Making Skills Assessment of respondents exposed to socio-scientific issue-based instruction in terms of social interaction.

In Scenario-based learning, the post-test scores demonstrate substantial improvement and high proficiency levels over the four-week period. In Week 1, 75% of the respondents scored within the "Highly Proficient" range (17-20). By Week 2, all respondents (100%) had achieved this level of proficiency. This trend indicates that the SBL approach rapidly and effectively enhances social interaction skills among participants. Furthermore, the remaining 25% of respondents in Week 1 fell into the "Proficient" category (13-16). However, by Week 2, none of the respondents remained in this category, as they had all transitioned to the "Highly Proficient" category. This shift suggests that Scenario-based Learning is particularly effective in not only improving but also sustaining high levels of social interaction skills.

One possible explanation for these results is the immersive nature of SBL. By placing students in realistic scenarios that require active participation and collaboration, SBL helps students develop practical social skills in a context that mirrors real-life interactions. For example, taking into account all activities in four weeks, learners relate to each other because the majority of the class share the same situation and experiences. They freely express and share their experiences during the natural phenomena discussed in the class such as volcanic eruption, earthquakes, extreme heat, typhoons, etc. thus, creating a seamless communication path within the group and the class. Moreover, this approach encourages students to apply their knowledge and skills in a social context, thereby enhancing their social interaction abilities through different learning activities. In the same case, the result can also be attributed to the fact the learners are already at ease with each other because they have been classmates since grade seven.

The results were aligned to the findings of Gehlbach et al. (2016) which demonstrated that scenario-based learning can significantly enhance social perspective-taking, which is a critical component of effective social interaction. Furthermore, Ritchhart and Church (2020) noted that scenario-based learning environments foster collaborative learning, where students actively engage with their peers in meaningful discussions, thus, enhancing their social interaction skills.

On the other hand, the Argument-Based Learning (ABL) approach also shows high levels of proficiency in social interaction skills. In Week 1, all respondents (100%) scored within the "Highly Proficient" range (17-20), and this level of proficiency was maintained throughout the subsequent weeks (Weeks 2 to 4). This consistency suggests that the ABL approach is highly effective in fostering and maintaining high levels of social interaction skills from the onset.

Similar to the SBL approach, no respondents fell into the "Proficient" (13-16), "Nearly Proficient" (9-12), "Low Proficient" (5-8), or "Not Proficient" (4 & below) categories at any time during the study. This uniformity highlights the robustness of the ABL method in ensuring that all participants achieve and sustain high proficiency levels in social interaction skills.

The success of ABL in social interaction skills may be attributed to the reason that the ABL approach emphasizes the importance of constructing and evaluating arguments in a collaborative setting. During the activities, students were required to communicate their ideas, listen to others, and engage in constructive dialogue. These activities naturally enhance students' social interaction skills, as they must navigate differing viewpoints and work towards a common understanding or resolution. In the activities, although learners argued in the context of ABL, they learned to respect the points of view of others. For example, in the presentation of arguments and debate in week 1 about the situation of the farmers in the Taal mountains, some groups said that the farmers needed to stay in the vicinity of Taal because of their livelihood while others pointed out that they needed to evacuate for their safety. In this activity, it was observed that the ABL approach did not only improve interaction in the class but also the open-mindedness and the flexibility to accept the opinions of others.

The effectiveness of the Argument-Based Learning approach in enhancing social interaction is supported by the results of Erduran and Jiménez-Aleixandre (2017) highlighting that argumentation-based learning promotes critical discourse among students, requiring them to engage deeply with their

peers' perspectives, thus enhancing their social interaction skills. Additionally, Osborne et al. (2019) found that structured argumentation tasks help students develop better communication and collaboration skills, which are essential for effective social interaction.

The consistently high proficiency levels achieved through both instructional methods suggest that integrating socio-scientific issues into the curriculum can be particularly beneficial for developing social interaction skills. These findings are supported by the broader educational literature, which emphasizes the importance of context-based and argumentation-based learning in fostering critical thinking, communication, and collaboration skills.

Table 4

Mean Post-test Scores of the Two Groups of Respondents exposed to Socio-scientific Issue-Based instruction.

Reasoning Skills	Scenario-based			Argument-based		
	mean	sd	Verbal Interpretation	mean	sd	Verbal Interpretation
Informal Reasoning	13.96	0.72	High Proficient	14.30	0.62	Highly Proficient
Evidence-based Reasoning	14.11	0.58	High Proficient	14.26	0.61	Highly Proficient
Social Interaction	17.44	0.49	High Proficient	17.69	0.49	Highly Proficient

Interpretation: Highly Proficient (14-16); Proficient (11-13); Nearly Proficient (8-10); Low Proficient (5-7); Not Proficient (0-4)/ Highly Proficient (17-20); Proficient (13-16); Nearly Proficient (9-12); Low Proficient (5-8); Not Proficient (0-4)

Table 4 shows the mean post-test scores for respondents exposed to socio-scientific issue-based instruction, focusing on different reasoning skills (informal reasoning, evidence-based reasoning, and social interaction), demonstrating differences in performance between Scenario-based Learning (SBL) and Argument-Based Learning (ABL).

For informal reasoning skills, the Argument-based Learning (ABL) group showed slightly higher mean scores (M = 14.30, SD = 0.62) compared to the Scenario-based Learning (SBL) group (M = 13.96, SD = 0.72). The smaller standard deviation in the ABL group suggests more consistent performance among respondents in this group.

During the conduct of the study, it was also observed that learners were more active in giving their insights in the ABL experimental group. This difference can be attributed to the nature of argumentation, which inherently involves informal reasoning as students develop and evaluate arguments. Osborne et al. (2019) emphasized that structured argumentation tasks enhance students' informal reasoning by requiring them to construct coherent arguments, assess the credibility of evidence, and engage in critical thinking. Therefore, ABL's emphasis on constructing and evaluating arguments likely contributed to the higher and more consistent informal reasoning scores.

In terms of evidence-based reasoning skills, the scores were again slightly higher for the ABL group (M = 14.26, SD = 0.61) compared to the SBL group (M = 14.11, SD = 0.58). Although the difference in means is modest, it suggests a slight edge for ABL in developing evidence-based reasoning skills.

Furthermore, the learners were motivated in ABL to prove their stand during debates thus making them more conscious of the data or evidence presented in the class. The effectiveness of ABL in this context is supported by Erduran and Jiménez-Aleixandre (2017), who noted that argumentation-based learning encourages students to rigorously analyze and use evidence to support their claims. This rigorous engagement with evidence likely explains the higher scores observed in the ABL group. Additionally, the slightly lower standard deviation in the ABL group indicates a more uniform improvement among students, reinforcing the robustness of this instructional method in teaching evidence-based reasoning.

For social reasoning skills, both groups achieved high mean scores, with the ABL group scoring marginally higher (M = 17.69, SD = 0.49) than the SBL group (M = 17.44, SD = 0.49). The identical standard deviations suggest a similar level of consistency in performance for both groups.

The high scores in social reasoning for both groups indicate that socio-scientific issue-based instruction is highly effective in this area, regardless of the specific approach. However, the slightly higher mean for the ABL group could be attributed to the interactive nature of argumentation, which often involves social negotiation and perspective-taking. Kuhn and Moore (2015) pointed out that engaging in argumentative discourse helps students understand and appreciate multiple viewpoints, thereby enhancing their social reasoning skills. This interaction likely explains the marginally higher scores in the ABL group.

Table 5

Test of Difference between the Post-test scores of the respondents exposed to Socio-scientific Issue-based Instruction

Reasoning Skills	Scenario-based		Argument-based		Mean Diff	t	Df	Sig. (2-tailed)	Verbal Interpretation
	mean	sd	mean	sd					
Informal Reasoning	13.96	0.72	14.30	0.62	-0.34	-2.25	78	0.027	Significant
Evidence-based Learning	14.11	0.58	14.26	0.61	-0.15	-1.13	78	0.262	Not Significant
Social Interaction	17.44	0.49	17.69	0.49	-0.25	-2.30	78	0.024	Significant

Table 5 presents the test of differences between the post-test scores in the reasoning skills assessment of the two groups of respondents exposed to socio-scientific issue-based instruction, such as scenario-based learning and argument-based learning.

Based on the results, it is shown that the two groups had significant differences in their mean post-test scores in both informal reasoning and social interaction skills, with p-values of 0.027 and 0.024, respectively.

Informal reasoning skills refer to reaching choices or inferences based on firsthand information, common sense, intuition, or other non-formal sources rather than with formal logic or well-structured arguments. Informal reasoning often deals with probabilistic reasoning, recognizing biases, evaluating sources of information, and understanding the nuances of arguments (Baron, 2018).

In this study, the students exposed to argument-based learning had a significant improvement in informal reasoning skills compared to those in the scenario-based learning group. This improvement can be attributed to the nature of argument-based learning, which emphasizes structured articulation and defense of ideas. In the context of the study, since the learners were tasked to create a plan or argument based on non-formal information from the community to be presented to the local authorities, they were prompted to reason based on their common sense and intuition. Non-formal information from their barangay helps them to form networks of ideas that support and substantiate their work. Furthermore, the information provided by the community was supported by evidence such as pictures of their houses with ash falls, news from Facebook, and others. This evidence strengthens the argument of students that led to a more concrete standpoint. Unlike scenario-based learning, which only involved interviews about the perception of their relatives about superstitions related to volcanic eruption, the learners were not prompted to defend their stand thus, yielding lower proficiency levels compared to ABL.

This result, supported by Kuhn (2015) emphasizes that structured argumentation tasks significantly enhance students' ability to reason informally by fostering critical thinking and reflective judgment. Similarly, Zohar and Nemet (2014) highlighted that engaging students in argumentative discourse helps them develop better reasoning skills, as they learn to construct, analyze, and evaluate arguments effectively.

On the other hand, evidence-based reasoning pertains to the ability to assess the credibility and relevance of information. This involves distinguishing between strong and weak evidence, understanding the reliability of sources, and integrating various pieces of information to form a coherent understanding.

In the context of the study, the difference in evidence-based reasoning skills between the two groups was not statistically significant (p=0.262). Both groups showed relatively similar mean scores, indicating that both scenario-based and argument-based learning were equally effective in enhancing this particular skill (Greene et al., 2028; Darling-Hammond, 2020)

In weeks two to four, both groups were exposed to different evidence to establish the existing problems in the lesson. Both experimental groups in SBL and ABL responded well in utilizing and evaluating evidence to support their reasoning during the class. For instance, documentary evidence of Taal eruption used in ABL yielded the same results as the evidence presented on the climate change topic in SBL because both of the groups maximized the use of the given data. Although, in terms of the mean, ABL has a slight edge over SBL maybe because the data given in Taal topic was in numerical form unlike in SBL where the information given was in the picture analysis. Both strategies encouraged learners to think critically about how these pieces of evidence can be maximized to support their substantiation.

According to Osborne et al. (2014), activities that involve the evaluation of evidence can significantly improve students' critical thinking skills. When students are exposed to tasks requiring them to analyze the quality and relevance of information, they become better equipped to discern credible sources from unreliable ones, which is a key component of scientific literacy.

Lastly, social interaction skills refer to the ability to effectively communicate, collaborate, and engage in discussions with others. This entails understanding different perspectives, negotiating, and building on others' ideas during interactions. Effective social interaction is vital for teamwork, problem-solving, and achieving common goals in both educational settings and real-world contexts (Johnson & Johnson, 2016).

In this research, students exposed to argument-based learning demonstrated significant improvement in social interaction skills compared to those in the scenario-based learning group. This improvement is likely due to the interactive nature of argument-based learning, which inherently involves discussions and exchanges of diverse viewpoints. The learners were more provoked to engage in collaboration and interaction in Argument-based learning because of the nature of the activities used in the class. For example, in week 1, learners were more expressive in the debates and the delivery of arguments exposing the different angles of the topic. It can also be reasoned out that in argument-based learning, learners recognize that there is a need to

communicate not only with their groupmates but also with the whole class. Furthermore, the students learned to respect each other's point of view on the issue which is vital to social interaction. Unlike scenario-based learning where students only collaborate without contradicting each other thus making the exchange of ideas in a single path with minimal opposition and challenge.

Vygotsky posits that social interaction plays a fundamental role in cognitive development, emphasizing that learning is a socially mediated process where students construct knowledge through interaction. Additionally, Mercer (2013) notes that dialogic teaching, which involves structured classroom dialogues, enhances students' ability to think together and build knowledge collectively.

Studies examining the effectiveness of scenario-based learning (SBL) and argument-based learning (ABL) have consistently demonstrated their positive impact on students' learning outcomes and critical thinking abilities. Greene et al. (2018) conducted a meta-analysis focusing on science and mathematics education and found that teaching with realistic contexts, a hallmark of SBL, led to significant improvements in students' understanding and application of science-mathematical concepts. Similarly, Darling-Hammond et al. (2020) emphasized the efficacy of SBL in teacher professional development, highlighting its role in fostering teachers' pedagogical knowledge and instructional practices. On the other hand, research on ABL has also yielded compelling evidence of its effectiveness in promoting critical thinking and reasoning skills among students. Osborne (2014) highlighted the role of collaborative, critical discourse in science education, demonstrating how argumentation within ABL frameworks can deepen students' understanding of scientific concepts and phenomena. Kuhn and Moore (2015) further emphasized the importance of argumentation in post-secondary classrooms, illustrating how ABL activities foster students' ability to construct and evaluate arguments, leading to more sophisticated reasoning abilities. Moreover, Sampson and Clark (2014) investigated the impact of collaboration on the outcomes of argumentation-based inquiry, revealing that ABL promotes collaborative problem-solving and enhances students' ability to engage in scientific reasoning.

CONCLUSION

The results indicate that argument-based learning was more effective in promoting informal reasoning and social interaction skills than scenario-based. The majority of respondents exhibited high proficiency in these areas, suggesting that this instructional approach effectively promotes critical thinking, logical argumentation, and collaborative skills. The high performance in informal reasoning implies that students benefitted from activities that required them to construct and deconstruct arguments and support their claims with evidence. Furthermore, the strong social interaction skills developed through argument-based learning reflect the success of this method in fostering effective communication and teamwork among students.

In contrast, scenario-based learning showed more varied results. While it facilitated some improvement in evidence-based reasoning, it was less effective in developing informal reasoning and social interaction skills. The absence of high scores in these areas indicates potential challenges in applying the skills within the scenario-based learning context, suggesting a need for additional support and scaffolding to enhance learner proficiency.

Comparative analysis confirmed that argument-based learning is more effective in developing informal reasoning and social interaction. This approach's structured and interactive nature contributed significantly to the higher proficiency levels observed in the respondents, making it a superior method for developing critical thinking, reasoning, and collaborative abilities.

The findings of this study led to the formulation of the conclusion of this study:

There is a significant difference between the mean post-test scores of the respondents in Argument-based learning and Scenario-based learning in terms of informal reasoning and social interaction. Thus, partially rejecting the null hypothesis.

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