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Enhancing students' argumentation skills using Socioscientific Issue (SSI)-based teaching in the respiratory system topic

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Abstract

This research aimed to enhance students' argumentation skills using socioscientific issue (SSI)-based teaching on the respiratory system topic. Participants were 12 grade 9 students of Maluso National High School who were purposively selected for the study. The research instruments used were an argumentation skill questionnaire and a specially designed SSI-based lesson plan on the respiratory system topic. For data analysis, the researchers used a *t*-test to find a significant relationship between the students' scores before and after the intervention. Findings revealed that out of 12 students, 8 (66.7%) were considered at a good level of argumentation after learning with SSIs. With a p value < .05, a significant difference was observed in the test scores of students before the integration of SSI-based lessons (M = 3.42, SD = 1.84) and post-instruction scores (M = 6.92, SD = 2.61); $t(11)$ = -9.23) suggesting improved argumentation leading to the conclusion of the study that the utilization of the developed respiratory SSI-based lesson during instruction inside the classroom can foster students' argumentation skills. Consequently, the researchers recommended further research, including longitudinal studies and exploration of different SSI topics to enhance teachers' understanding of the sustained impact and generalizability of SSI-based teaching in fostering students' argumentation skills.

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Introduction

The K-12 curriculum aims to improve students' scientific knowledge, which enables students to become knowledgeable, engaged citizens who can make well-informed decisions about the applications of scientific knowledge that could influence society, the environment, or health (Department of Education, 2019). Students must improve argumentation and reasoning skills to effectively engage in public debate and intellectual discussion and enhance efficient decision-making. This can only be attained if the science teacher is fully equipped with both pedagogical approaches and content knowledge (Lualhati, 2017), such as teaching Socioscientific Issues (SSIs) inside the classroom where it addresses controversial conflicts (Presley et al., 2013) concerning physical and social life that are morally and science-based issues by bridging scientific content with moral and ethical perspectives engaging higher-order cognitive practices in the classroom such as reasoning and decision making (Zohar & Nemet, 2002). It includes moral judgment, problem-solving (Presley et al., 2013), and debates that result in students' reflection on their experiences and the underlying concepts in science (Serpell, 2011).

SSI-based pedagogy works and aims as a science education curriculum to create environmentally conscious, technologically adept, and scientifically knowledgeable people (Lee et al., 2006) who are: (1) Critical problem solvers who can make informed decisions about the issues; (2) Responsible stewards of nature who can readily apply scientific knowledge, such as the content of science and society, to a local and global context; and (3) Innovative and creative citizens who can perform scientific procedures and possess abilities like argumentation, modeling, and demonstrating scientific attitude, values, and morals as effective communicators.

Still, it has been viewed as challenging pedagogy as it requires familiarity, mastery, and even time (Pitiporntapin et al., 2016); apart from the fact that most studies on SSI across the fields such as the debatable issues on genetic engineering (Sadler & Donnelly, 2006; Sadler & Zeidler, 2005) environmental science (Uskola et al., 2010), and electromagnetic waves (Kolstø, 2006) are found to have positive results for students' argumentative skills, students can acquire knowledge to offer reasonable justifications, restrict their choices, or substitute alternatives. According to Presley et al. (2013), a proponent who created the SSI-based framework, Topçu et al. (2018) stated that the following were essential components of SSI-based instruction: (1) Creating an engaging curriculum centered around an intriguing topic; (2) Drawing attention to the problem at the outset of instruction; (3) Emphasizing teaching science concepts and getting students involved in scientific activities like debate; (4) Allowing students opportunities to use media to gather and evaluate information about the issue; and (5) Assisting students in navigating the societal dimensions of the problem.

According to sources referenced in Topçu et al. (2018), the teaching approach's three main focuses are as follows: First, fostering students' comprehension of science conceptually (Klosterman & Sadler, 2010; Topcu & Genel, 2014). Second, students' scientific thinking was advanced by including them in higher-order science activities, such as reasoning, arguing, and making decisions (Walker & Zeidler, 2007; Zeidler & Nichols, 2009). Finally, SSI, as argumentation in nature, developed a solid comprehension and addressed the social aspects of the problem. Though a detailed definition of argumentation has yet to be fully established within the scholarly works (Mcdonald, 2010), it was generally understood to be a statement, claim, and evidence to support it (Driver et al., 2000). Argumentation is a process of constructing arguments between individuals or engaging in debate on opposing claims. Osborne (2010) argued that an argument's supporting aspects might be rebutted or countered, necessitating the capacity to discern, evaluate, and compare several lines of argument. Argumentation helps students build new understandings by comparing and contrasting old and new ideas (Osborne, 2010). The National Research Council (NRC, 1997) described argumentation as an essential element of knowledge in science, helping students develop arguments and reasoning skills so they can make informed decisions on local and global issues that affect both individuals and society.

Consequently, teaching the students argumentation skills helps them build sound scientific arguments and link those abilities with socioscientific information. One example is as follows: Human respiratory issues are caused by smoking cigarettes. It is reported that over eighty percent of smokers begin the habit before they turn nineteen. They believe that smoking is a healthy habit that promotes calmness. According to Infondation (2013), even though electronic cigarettes are just as deadly as tobacco cigarettes, some people also use them. Although the majority of smokers cite stress relief as a perceived benefit and motivation for smoking (Fidler & West, 2009), the nicotine withdrawal symptoms can cause psychological discomfort, such as irritability, anxiety, and depression (Benowitz, 2010). Smokers may mistakenly believe that relieving

their withdrawal symptoms will relieve the stress; quitting smoking can reduce stress and improve mental health (Taylor et al., 2014). Hence, teaching the correct way to mitigate nicotine withdrawal symptoms and educating smokers about the negative effects and benefits of quitting smoking is highly recommended (Fidler & West, 2009). Students could better defend their positions and argue challenging problems (Lin & Mintez, 2010). When classroom debates involve more assertions and argumentation, students improve their decision-making abilities (Duschl & Osborne, 2002; Kuhn, 1993).

On the other hand, a recent needs assessment study conducted by Kolong et al. (2022) demonstrated that science teachers and students are unfamiliar with SSIs. The majority of educators are unfamiliar with SSIs and do not instruct their students in SSI-based courses; as such, students have no exposure to SSIs. Additionally, the teaching materials are still lacking and do not meet the demands of the modern classroom. This lack is especially evident in topics related to increasingly complex respiratory system disorders that affect people, particularly those brought on by exposure to tobacco and electronic cigarettes. While students may already be aware of the health risks associated with e-cigarettes, their concerns and understanding have remained the same and unchanged (Nuha & Lisdiana, 2019).

In addition, according to Presley et al. (2013), a proponent who created the SSI-based framework, the following are the essential components of SSI-based instruction: (1) Creating an engaging curriculum centered around an intriguing topic; (2) Drawing attention to the problem at the outset of instruction; (3) Emphasizing teaching science concepts and getting students involved in scientific activities like debate; (4) Allowing students opportunities to use media to gather and evaluate information about the issue; and (5) Assisting students in navigating the societal dimensions of the problem.

Essentially, the SSI-based teaching framework featured four critical components: the Design Element, Learning Experiences, Teacher Attributes, and Classroom Environment. The first fundamental element is the Design Elements, which emphasizes that instruction should be a compelling social issue with strong scientific links, and that is introduced at the outset of instruction, providing a genuine context for learning. For example, in this research, the topic of diseases and issues in the respiratory system is commonly discussed at the end of the respiratory topic. However, the purpose of SSI-based teaching is lost if related problems are brought up after the lesson. The foundation of SSI-based education is giving students access to real-world contexts to understand the social aspects of the scientific topic of respiratory system. By means of a real-world experience, students will develop abilities applicable outside of the classroom and acquire a deeper understanding of the content (Sadler, 2011). SSI only suffices if a socio-scientific issue is central to the curriculum or instruction. Providing scaffolding is advised in a design feature to encourage student participation in higher-order practices. The Framework also outlines essential learning experiences and opportunities, such as: (1) Using higher-order reasoning, argumentation, decision-making, and position-taking; (2) Addressing scientific theories and ideas relating to the issue at hand; (3) Gathering and interpreting scientific facts on the subject; and (4) Addressing societal (political and economic) aspects of the issue. Effective SSI-based education requires learners to engage in activities that foster higher-order behaviors such as reasoning, argumentation, decision-making, and position-taking (Walker & Zeidler, 2007). Providing students with opportunities to practice these skills is a crucial component of SSI-based education. Nevertheless, it is challenging to engage students in complex, higher-order thinking; thus, teachers should not expect students to have these skills mastered immediately. There must be a constant involvement of SSI activities in teaching science concepts, as well as various ways in which scaffolding can aid in developing these abilities (Quintana, 2004). As students' progress toward more complex forms of reasoning, for instance, technology tools such as computers and mobile phones can help students make connections between claims and evidence (Tal et al., 2011). Scaffolds can also be organized to help learners analyze multiple viewpoints while attempting to determine their stance on a contentious issue (Eastwood et al., 2011), providing possible scaffolds for higher-order practices. the framework recommends scaffolding to support students' thought and practice, but does not specify a specific style. The final design feature should be a concluding experience that lets learners apply their knowledge to the issue. Role-play, discussion, and service-learning enable students to reflect on and apply higher-order behaviors independently of the arrangement (Eastwood et al., 2012). SSI offers two recommended design characteristics in addition to the fundamentals. Basic design features are necessary for SSI-based education, although recommended design elements are optional. Some suggestions: (1) Applying classroom activities to life, and (2) Teaching students with technology. Media tools enable teachers to provide a more diverse range of sources and help students connect classroom learning to current events (Klosterman et al., 2012).

In this study, students utilize newspaper articles and TV reports to learn about societal concerns related to the respiratory system, and then use their phones to research related material to better comprehend the information. Cell phones and Wifi allow students to generate and evaluate solid, argumentative information. Technology enhances SSI-based teaching and introduces relevant social subjects (Evagorou, 2011). Technology helps students and specialists network across geographies (Chen et al., 2010), giving students and teachers access to varied media.

Next, teacher attributes. Along with instruction design and learner experiences, the teacher must have specific traits to facilitate SSI-based instruction in the classroom. Teachers must understand the science and social aspects of the SSI they teach. Teaching science in context requires subject knowledge (Lee & Witz, 2009). To teach SSI-based respiratory system topics, teachers must understand scientific principles, including how nicotine and other toxic chemicals affect organs, tissues, and the environment. Successful SSI instruction requires teachers to comprehend social issues (Barrett & Nieswandt, 2010).

The classroom environment, on the other hand, is the second layer of the SSI framework and significantly impacts the fundamental features (design elements, learning experiences, and teacher qualities) that contain the necessary norms and expectations for SSI implementation in local learning contexts. To foster this environment, assign roles to students and facilitate engaging activities. Promoting student participation and accountability through collaborative activities is a crucial second aspect. Encouraging group discussions, presentations, and argumentation can increase student engagement and accountability (Aufschnaiter et al., 2008). For effective SSI teaching, the teacher and students must cultivate mutual respect and safety; establishing a classroom characterized by high expectations, collaboration, and a culture of respect and safety requires time, teacher motivation, and student commitment (Zeidler et al., 2011).

The third and outer layer of the SSI framework, Other Peripheral Influences, includes characteristics that significantly impact the core components (design elements, learning experiences, and teacher traits) and the classroom environment (the second layer). Influences from school, community, and state/national legislation can impact SSI-based instruction. The school and district can significantly affect the implementation of SSI-based curricula. Teachers may hesitate to try new instructional strategies, so school and district support is crucial for their success (Johnson, 2006; Khourney-Bowers et al., 2005). To implement SSI-based education, teachers need access to quality curricula and materials. Access to high-quality SSI resources is crucial for teachers who lack the time or knowledge to design curricular materials (Beyer & Davis, 2012; Fogleman et al., 2011). Additionally, community consumers may encourage instructors or administrators to reject SSI-based training if they find a local issue or topic controversial (Hughes, 2000). Teachers and school staff must develop solutions to address these concerns. Teachers and administrators can meet with parents and community members to convey the importance of learning about the issue (the fifth fundamental quality of peripheral influences). The SSI-based teaching framework suggests extra learning opportunities as shown in Figure 1.

Despite the efficiency of the SSI to be facilitated inside the classroom by teachers and enhancing students' higher-order practices such as argumentation, reasoning and decision making, the researchers have found not enough studies related to the development of Socio-Scientific Issues (SSI) particularly issues revolving around the Respiratory system in the Junior High. This endeavor motivates the researchers to further investigate students' argumentation before and after the integration of Respiratory SSIs inside the classroom.

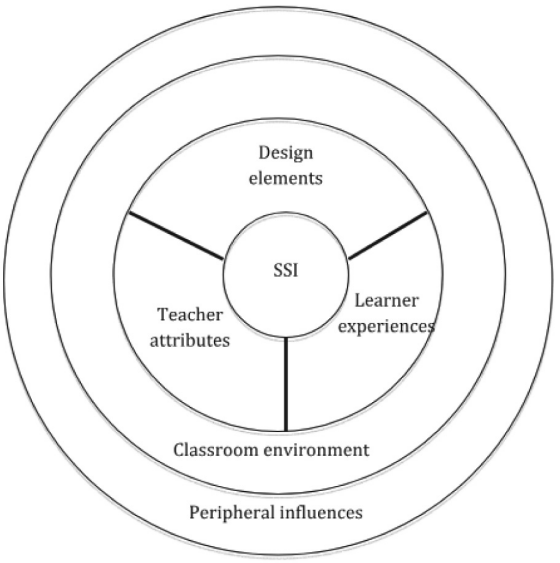

Figure 1 The graphical representation of SSI-based teaching framework
Source: Adapted from Presley et al. (2013).

Research Questions

The study aimed to enhance students' argumentation skills through SSI-based teaching in the Respiratory system among Maluso National High School grade 9 students during the academic year 2021–2022. It specifically aimed to respond to the following research questions: (1) what is the level of students' argumentation skills during the pretest and Posttest? and (2) is there a significant relationship between the pretest and posttest scores?

Methodology

Research Design

Quasi-experimental research using a pretest-posttest design was used to test the effectiveness of an intervention on the students' argumentation skills such as in providing claim and warrant, counterargument, support argument/ rebuttals, and providing evidence. A purposive sampling method was employed in the study, where respondents (n=12) were selected from naturally occurring group sections on a grade level and volunteerism to join the lesson and activity at all times of teaching.

Research Instruments

A specially designed SSI-based teaching lesson plan on the respiratory system, SSI focused on the Respiratory system in science grade 9, which aimed to understand the Respiratory system and its interaction with the circulatory system in giving the body the nourishment it needs for energy, diseases that result from harmful substances, prevention and treatment, including its social issues. The researcher used this content standard to discuss and incorporate SSIs, such as the Banning of Cigarettes and Smoking in Public Places, believed to lessen Lung Cancer cases in the community.

The SSI-based lesson plan was anchored on the SSI model of Eilks (2010), following the five basic steps for instruction: (1) Problem analysis: In this step, students were exposed to a topic of interest through media stories or additional strategies that emphasized the actuality and significance of the issue; (2) Clarification of science: Teachers facilitated students' understanding of the fundamental scientific principles that underlie the issue; (3) Refocus on the socio-scientific dilemma: Students redirected their attention towards the subject and the related societal problems or conflicts; (4) Role-playing task: Students took on responsibilities in the SSI bargaining process. These roles may include participants in the issue debate or creators of issue-related media; and 5) Meta-reflective activity: Students are urged to think about their overall experiences with the issue and the science behind it. This model was chosen for two reasons: (1) It allowed students to reflect on the overall activities they had undergone and prior experiences on the issues and knowledge of science; and (2) It was very manageable for teachers and found to be appealing to the students because of its role-play activity, where students were given the chance to act as problem experts and solvers, trying to persuade an audience (classmates) with the idea through proper reasoning and argumentation.

In crafting the lessons, competencies, and objectives had to be mapped to decide what specific social issues may be incorporated into the science topics. As to the objectives of the lesson, the researcher mapped the related competencies of the Respiratory system. And, with the help of the curriculum guide, the teacher associated competencies and related social issues about the topic of the Respiratory system. The developed lesson plan was validated by the three science experts. Criteria included the following: (1) The property of the lesson plan, (2) The contextualization of the activities, and (3) The usefulness of the developed lessons and strategies. Contextualization acquired a general average of 4.0, rated as strongly agreed and interpreted as Excellent and ready for implementation.

Students' Argumentation Skills Questionnaire (SASQ)

Open-ended questions based on the socio-scientific issues of the Respiratory system were used. Questions were adapted from Lin and Mintzes (2010) to assess students' ability to argumentation and its components such as providing Claim and warrant, constructing counter-arguments, supporting arguments, and formulating evidence to support claims. There were two main parts of the questionnaire: (1) Scenario part where issues were laid out usually in paragraph form introducing the disputable problem to the reader; and (2) where 4 open-ended questions were raised; questions that corresponded to the 4 components of the argumentation to argumentation. Questions were drawn from Respiratory main SSI such as whether the Banning of Smoking in public areas can protect everyone from having lung cancer.

To assess students' argumentation skills level, an argumentation rubric which had 4 distinct levels; Excellent, Good, Fair, and Poor (unsatisfactory) was used to quantify and assess components in the argumentation.

Each level was supported by the 4 major argumentative frameworks, assessed based on (1) Claim and warrant, (2) Evidence presented, (3) The counterargument that is being made, and (4) Supportive argument or qualifier. The argumentative framework of Lin and Mintzes has been widely used in many studies, because of its general applicability, which enables students to explore both supporting and refuting their own claims (Songil et al., 2019).

Data Collection

Respondents and parents were given consent letters for study ethics, which were then approved by the school administration. The endorsement of the school principal, as well as other prerequisites, has been given to the Ministry of Basic, Higher, and Technical Education-Basilan Schools Division for approval. Before the survey began, research participants were briefed on the purpose of the study and the data that would be collected. The pre-argumentation descriptive test was administered to student respondents and content was analyzed using Lin and Mintzes' (2010) argumentation level rubrics. Before students could take their post-argumentation descriptive test, they had to go through a one-week intervention. Descriptive data had been assessed, categorized depending on argumentation level, and descriptively analyzed using rubrics.

Data Analysis

Quantitative data from students' argumentation skill descriptive test data were scored numerically on the argumentation rubric with four unique levels: Excellent, Good, Fair, and Poor (unsatisfactory) to determine the students' degree of argumentation skills. The four main argumentation frameworks provided support for each level. The evaluation criteria are as follows: (1) Claim and warrant, (2) Evidence offered, (3) The counterargument being made, and (4) Supportive argument or qualifier. For instance, when a student was asked the question on whether he agreed or disagreed with the banning of smoking in public places and then answered the question with "yes, I agree", then the researcher would give 1 point for his answer due to only one acceptable claim but with no warrant supporting his claim. But when the student would answer the question with "yes, I agree because it is not good for our health" or "it may cause others to be sick too", the researcher would give + point for an additional warrant. Moreover, collected numerical data were subjected to statistical treatments such as mean, standard deviation, and paired T-test to see statistical relationships in the obtained data.

Results

The researcher scored students during their pretest and post-test to assess their argumentation skills to SSI on respiratory topics tackled inside the class. A paired t-test was used to see the significant relationship between paired variables and to determine whether the integration of the instruction of SSIs helped them improve. Below, Table 1 shows a statistical report on students' performance and argumentation skill levels during the implementation of the intervention.

Table 1 Differences in the performance of the students' argumentation

Paired Variables	*M*	*SD*	*t*	*df*	*p*	Remarks
Pre-Test	3.42	1.84	-9.23	11	.000	Significant
Post-Test	6.92	2.61				

Note: $p < .05$.

Table 1 shows the statistical inference using the paired t-test on the sampled students' average pre-test scores and post-test scores during the pilot testing. It was reflected that $t = -9.23$, with p value $< .05$, made a notable difference in the post-test scores (after the implementation of SSI) and the pre-test scores of the sampled students. We can conclude that there was a statistically significant improvement in the students' test scores from to, following improvement in each argumentation component. The results revealed that using SSI-based lessons had a significant impact on students' argumentation skills. The improvement followed the SSI-based instruction as manifested in the individual average score of the student in the pre-test and post-test. Evidence from Zohar and Nemet (2002) showed enhancements in learners' abilities and the level of their reasoning when they received explicit instruction in argumentation (SSI) within scientific contexts. Indeed, explicit instruction of SSI has had a positive impact and contributed to enhancing students' argumentation skills and their level. Moreover, Table 2 below provides evidence of the levels of students' argumentation skills before and after engaging with SSIs in class discussions.

Table 2 Percentage levels students' argumentation skills before and after learning with SSI on respiratory topic

Before			After		
Level	No.	%	Level	No.	%
Excellent	0	0.0	Excellent	2	16.7
Good	2	16.7	Good	6	50.0
Fair	8	66.7	Fair	4	33.3
Unsatisfied	2	16.7	Unsatisfied	0	0.0
Total	12	100.0	Total	12	100.0

The table indicates the total argumentation skill of the students (n = 12) during the tryout study. A total of 8 students (66.7%) achieved a high proficiency level, as indicated by instruction using the SSI-based teaching approach. During the instruction, students delved into the components of argumentation and examined thought-provoking topics surrounding respiratory health, incorporating technology integration. Students have developed a firm grasp of the subject matter and have honed their ability to support their viewpoints during a role-playing exercise. During the role-playing presentation, students could connect scientific concepts with their moral and ethical views (Zohar & Nemet, 2002). They gained a deeper understanding of science by reflecting on their experiences and the underlying principles (Serpell, 2011). This suggests that there must have been a continuous incorporation of high-order thinking practices to push the students to think critically and delve into issues on a deeper level, ultimately shaping them into responsible and knowledgeable members of society capable of generating, synthesizing, and evaluating information. Teachers must receive professional development programs from the beginning to enhance their ability to incorporate SSIs into their teaching. This is because it requires a deep understanding and consideration of the social aspects of the issue in order to help students grasp scientific concepts (Klosterman & Sadler, 2010; Topcu & Genel, 2014) and enhance their critical thinking in science (Walker & Zeidler, 2007; Zeidler & Nichols 2009). These results placed much attention on the researcher to conduct further direct implementation to see the data consistency and clarify further argumentation skill levels among students. According to Osborne et al. (2004), explicit instruction on argumentation within the science curriculum for a sustained period is recommended to enhance students' ability to argue effectively substantially. To support the above data further, shows the results of the paired variable in each argumentation component.

The table showed the statistical inference Pre-Test and Post-test Scores per Question (from Questions 1 to 4). It reflected that there was a significant difference in the pre-test and post-test scores per question during the tryout implementation, with t = 3.924 and p value = .002 < .05 for Q1, t = -3.527 and p value = .005 < .05 for Q2, t = -4.168 and p value = .002 < .05 for Q3, and t = 3.752 and p value = .003 < .05. The results concluded that there was an improvement in test scores per question. For Question 1, from 1.42 ± .515 to 2.00 ± 0.853, for Question 2, from 0.75 ± 0.754 to 1.67 ± 0.985, for Question 3, from 0.58 ± 0.669 to 1.67 ± 0.492, and Question 4, from 0.67 ± 0.492 to 2.00 ± 1.348. Also, the highest score for the post-test was under Question 1 and 2 with both a mean of 2.00 and a standard deviation of 0.853 and 1.348 respectively, suggesting that students can provide warrants in each component of argumentation and support the claim by providing more than one piece of evidence to support their claim. The improved scores performance were indicated by mean and standard deviation; and depict enhanced performance. Students statistically improved in Posttest Q1 and Q4, revealing that students can provide more warrants and pieces of evidence in supporting their claims after learning with SSI-based lessons.

Table 3 Differences in students' performance test scores per question (Component of argumentation) before and after the integration of SSI-based lesson ssing the paired t-test

Paired Variable	*M*	*SD*	*t*	*df*	*p*	Remarks
Q1-Claim & Warrant						
Pretest	1.42	0.515	-3.924	11	.002	Significant
Posttest	2.00	0.853				
Q2-Counterargument						
Pretest	0.75	0.754	-3.527	11	.005	Significant
Posttest	1.67	0.985				
Q3- Supportive Argument/Rebuttal						
Pretest	0.58	0.669	-4.168	11	.002	Significant
Posttest	1.67	0.985				
Q4-Evidence						
Pretest	0.67	0.495	-3.752	11	.003	Significant
Posttest	2.00	1.347				

Note: p < .005.

Discussion

Students significantly improved the quality of their answers after learning SSI. By teaching students the components of argumentation skills, they can develop the ability to generate scientifically valid arguments and effectively apply such thinking abilities to address specific socio-scientific issues (SSIs); they exhibit the enhanced capacity to rationalize their stances on the matters at hand (Lin & Mintzes, 2010).

The findings from Table 1 indicate a notable improvement in students' ability to construct and present convincing evidence following the implementation of SSI-based lessons, signifying a noteworthy enhancement in students' performance after exposure to SSI-based instruction. The favorable results are consistent with the previous assertions, which highlight the significance of instructional strategies that are explicitly based on SSI in the field of scientific and educational research, which illustrated that explicit SSI-based instruction in scientific contexts has a beneficial effect on students' argumentation abilities (Osborne et al., 2004; Zohar & Nemet, 2002). The conclusions that the SSI-based courses significantly and positively impacted students' argumentation skills are supported by the statistical evidence.

The findings also show that 66.7 percent of students had solid reasoning skills during the instruction, highlighting the positive effects of SSI-based training. These results demonstrate the consistency and efficacy of the educational technique, prompting the researcher to implement it and study student argumentation skills. This is true, just like most other studies on SSI in other fields (Sadler & Donnelly, 2006; Sadler & Zeidler, 2005; Uskola et al., 2010). After engaging with SSIs, students usually have the capacity to articulate compelling arguments, recognize the limitations of their choices, and suggest different approaches, improving and advancing their scientific and conceptual knowledge (Walker & Zeidler, 2007; Zohar & Nemet, 2002). In addition, the findings reveal substantial gains in scores for every question on the component of argumentation, suggesting that the student respondent performed more effectively in substantiating claims with warrants, evidence, and support. Questions about providing evidence exhibited the highest post-test scores, indicating that students who learned concepts through SSI-based instruction demonstrated exceptional proficiency in furnishing evidence to substantiate their assertions. The students could optimize their gadgets during the activity and explore issues with the help of the internet and search engines although some students found it difficult to access an internet connection. As it required some proficiency in using technology, students did well across the board, with evidence being a solid area of progress. Sustaining evidence has also been a problem, as students must comprehend the substance of the evidence and interpret the possible potential correlation to the made claim (Sandoval & Millwood, 2005). Only a few students can generate multiple pieces of evidence to support claims, as rendering is the most challenging aspect of reasoning (Lin & Mintzes, 2010).

Notably, they excelled in providing evidence, which made it first among the components, followed by their ability to articulate claims and warrants. This success can be attributed to the questionnaire's scenario-based approach, in which students were given real-world scenarios and accompanying data for analysis. This contextualized learning environment enhanced their ability to support arguments effectively by drawing on relevant evidence. The findings indicate that SSI-based instruction enhanced students' abilities to apply theoretical knowledge to practical circumstances while supporting their statements with substantial evidence.

On the other hand, students have less mastered rebuttal/support argument even after learning with SSIs due to an inability to recognize the distinction between counterargument and support argument. According to Kuhn (1993), one must evaluate a proposition and its corresponding opposing viewpoint before formulating counterarguments. Students tended to misuse expanded or supplemental warrants as evidence if given less consideration. This was well demonstrated in the study in that 5.8 percent of all low achievers had the same problem during the posttest, which suggested the students had not understood what a counterargument was (Lin & Mintzes, 2010).

Conclusion

According to the study's findings, SSI-based lessons have been shown to help improve students' reasoning skills, and there is significant evidence supporting this effectiveness. The quantitative statistics, supported by statistical studies, demonstrate a considerable improvement in overall test scores and performance on specific aspects of reasoning. The findings contribute to the existing body of knowledge on SSI and highlight the practical implications for teachers seeking to enhance their students' reasoning abilities. The fact that students have demonstrated clear improvements in their ability to

provide warrants, evidence, and support for statements highlights the potential of education based on SSI to boost students' critical thinking and scientific reasoning. Furthermore, future studies could investigate the efficacy of SSI-based training across various scientific disciplines to determine whether the reported gains are topic-specific or applicable across a more extensive range of subjects. A descriptive exam was employed in this study; however, incorporating varied assessment methods, such as project-based evaluations, portfolios, debate and real-world applications, may provide a more comprehensive evaluation of students' argumentation skills. Further research and longitudinal studies could provide more insights into the long-term effects of SSI-based training on students' reasoning skills and their overall scientific literacy. Further research and studies could be conducted in the future.

Conflict of Interest

The authors declare that there is no conflict of interest.

Acknowledgments

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References

Aufschnaiter, C. V., Erduran, S., Osborne, J., & Simon, S. (2008). Arguing to learn and learning to argue: Case studies of how students' argumentation relates to their scientific knowledge. *Journal of Research in Science Teaching*, *45*(1), 101–131. https://doi.org/10.1002/tea.20213

Barrett, S. E., & Nieswandt, M. (2010). Teaching about ethics through socioscientific issues in physics and chemistry: Teacher candidates' beliefs. *Journal of Research in Science Teaching*, *47*(4), 380–401. https://doi.org/10.1002/tea.20343

Benowitz, N. L. (2010). Nicotine addiction. *New England Journal of Medicine, 362*, 2295–2303. https://doi.org/10.1056/NEJMra0809890

Beyer, C. J., & Davis, E. A. (2012). Learning to critique and adapt science curriculum materials: Examining the development of preservice elementary teachers' pedagogical content knowledge. *Science Education*, *96*(1), 130–157. https://doi.org/10.1002/sce.20466

Chen, W., Seow, P., So, H-J., Toh, Y., & Looi, C-K. (2010). Connecting learning spaces using mobile technology. *Educational Technology*, *50*(5), 45-50. https://hdl.handle.net/10497/13846

Department of Education. (2019). *Policy guidelines on the K to 12 basic education program* (DepEd Order No. 21, s. 2019). Author. https://www.deped.gov.ph/wp-content/uploads/2019/08/DO_s2019_021.pdf

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education*, *84*, 287–312. https://doi.org/10.1002/(SICI)1098-237X(200005)84:3<287::AID-SCE1>3.0.CO;2-A

Duschl, R., & Osborne, J. (2002). Supporting and promoting argumentation discourse in science education. *Studies in Science Education*, *38*(1), 39–72. https://doi.org/10.1080/03057260208560187

Eastwood, J. L., Schlegel, W. M., & Cook, K. L. (2011). Effects of an interdisciplinary program on students' reasoning with socioscientific issues and perceptions of their learning experiences. In T. Sadler (Ed.), Socio-scientific issues in the classroom: Teaching, learning and research (pp. 89-126). New York: Springer.

Eastwood, J. L., Sadler, T. D., Sherwood, R., & Schlegel, W. M. (2012). *Students' participation in an interdisciplinary, socioscientific issues-based undergraduate human biology major and their understanding of scientific inquiry*. Research in Science Education. https://doi.org/10.1007/ s11165-.02-9298

Eilks, I. (2010). *Making chemistry teaching relevant and promoting scientific literacy by focusing on authentic and controversial socio-scientific issues* [Paper presentation]. The Annual Meeting of the Society for Didactics in Chemistry and Physics, Potsdam, Germany.

Evagorou, M. (2011). Discussing a socioscientific issue in a primary school classroom: The case of using a technology-supported environment in formal and nonformal settings. In T. D. Sadler (Ed.), *Socio-scientific issues in the classroom: Teaching, learning and research* (pp. 133–159). Springer. https://doi.org/10.1007/978-94-007-1159-4_8

Fidler, J. A., & West, R. (2009). Self-perceived smoking motives and their correlates in a general population sample. *Nicotine & Tobacco Research*, *11*(10), 1182–1188. https://doi.org/10.1093/ntr/ntp120

Fogleman, J., McNeill, K. L., & Krajcik, J. (2011). Examining the effects of teachers' adaptations of a middle school science inquiry-oriented curriculum unit on student learning. *Journal of Research in Science Teaching*, *48*(2), 149–169. https://doi.org/10.1002/tea.20399

Hughes, G. (2000). Marginalization of Socio-Scientific Material in Science-Technology-Society Science Curricula: Some Implications for Gender Inclusivity and Curricula Reform. *Journal of Research in Science Teaching*, *37*, 426–440. http://dx.doi.org/10.1002/(SICI)1098-2736(200005)37:5<426::AID-TEA3>3.0.CO;2-U

Infondation. (2013). *Perilaku Merokok Masyarakat Indonesia Berdasarkan Riskesdas 2007 dan 2013*. Pusat Data dan Informasi Kementrian Kesehatan RI.

Johnson, C. C. (2006). Effective professional development and change in practice: Barriers science teachers encounter and implications for reform. *School Science and Mathematics*, *106*(3), 150–161. https://doi.org/10.1111/j.1949-8594.2006.tb18172.x

Khourney-Bowers, C., Dinko, R. L., & Hart, R. G. (2005). Influence of a shared leadership model in creating a school culture of inquiry and collegiality. *Journal of Research in Science Teaching*, *42*, 3–24. https://doi.org/10.1002/tea.20038

Klosterman, M. L., & T. D. Sadler. (2010). Multi-level assessment of scientific content knowledge gains associated with socioscientific issues-based instruction. *International Journal of Science Education*, *32*(8), 1017–1043. https://doi.org/10.1080/09500690902894512

Klosterman, M., Sadler, T., & Brown, J. (2012). Viral news: Media literacy for the 21st century. *Science Scope*, *35*(9), 61–69. https://eric.ed.gov/?id=EJ996848

Kolong, A. I, Hairulla M. S, & Pitiporntapin S. (2022). Science teachers and students' perspectives on SSI-based instruction: Basis on the development of SSI-based curricular resources. *Thabiea: Journal of Natural Science Teaching*, *6*(1), 1–24. http://dx.doi.org/10.21043/thabiea.v6i1.18215

Kolstø, S. D. (2006). Patterns in students' argumentation confronted with a risk-focused socioscientific issue. *International Journal of Science Education*, *28*(14), 1689–1716. https://doi.org/10.1080/09500690600560878

Kuhn, D. (1993). Science as argument: Implications for teaching and learning scientific thinking. *Science Education*, *77*, 319–337. https://doi.org/10.1002/sce.3730770306

Lee, H., Abd-El-Khalick, F. & Choi, K. (2006). Korean science teachers' perceptions of the introduction of socio-scientific issues into the science curriculum. *Canadian Journal of Science, Mathematics and Technology Education*, *6*, 97–117. https://doi.org/10.1080/14926150609556691

Lee, H., & Witz, K. G. (2009). Science teachers' inspiration for teaching socio-scientific issues: Disconnection with reform efforts. *International Journal of Science Education*, *31*(7), 931–960. https://doi.org/10.1080/09500690801898903

Lin S., & Mintzes J. J. (2010). Learning argumentation skills through instruction in socioscientific issues: The effect of ability level. *International Journal of Science and Mathematics Education*, *8*(6), 993017. https://doi.org/10.1007/s10763-010-9215-6

Lualhati, G. P. (2017). Filipino student teachers' environmental competencies: Basis for development of a training module. *Asia Pacific Journal of Multidisciplinary Research*, *5*(1), 62–72. https://www.semanticscholar.org/paper/Filipino-Student-Teachers'-Environmental-Basis-for-Panganiban Lualhati/a5acd96f7e607c6dadcbcb2995920ff601e0f417

McDonald, C. V. (2010). The influence of explicit nature of science and argumentation instruction on preservice primary teachers' views of nature of science. *Journal of Research in Science Teaching*, *47*(9), 1137–1164. https://doi.org/10.1002/tea.20377

National Research Council (NRC). (1996). *National science education standards*. National Academy Press.

Nuha, U., & Lisdiana, L. (2019). The development of respiratory system teaching material supplement as a caring form of the dangers of e-cigarettes for health. *Journal of Biology Education*, *8*(2), 196–208. https://doi.org/10.15294/jbe.v8i2.31463

Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. *Journal of Research in Science Teaching*, *41*(10), 994–1020. https://doi.org/10.1002/tea.20035

Osborne, S. (2010). *The new public governance: Emerging perspectives on the theory and practice of public governance*. Routledge.

Pitiporntapin S., Yutakom N., & Sadler T. D. (2016). Thai pre-service science teachers' struggles in using Socio-scientific Issues (SSIs') during practicum. *Asia-Pacific Forum on Science Learning and Teaching*, *17*(2). https://eric.ed.gov/?id=EJ1145733

Presley M. L., Sickel, A. J., Muslu, N., Johnson, D. M., Witzig, S. B., Izci, K., & Sadler, T. D. (2013). A framework for socio-scientific issues-based education. *Science Education*, *22*(1), 26–32. https://eric.ed.gov/?id=EJ1062183

Quintana, C., Reiser, B. J., Davis, E. A., Krajcik, J., Fretz, E., Duncan, R. G., Kyza, E. A., Edelson, D. C., & Soloway, E. (2004). A scaffolding design framework for software to support science inquiry. *Journal of the Learning Sciences*, *13*(3), 337–386. https://doi.org/10.1207/s15327809jls1303_4

Sadler, T. D., & Donnelly, L. A. (2006). Socioscientific argumentation: The effects of content knowledge and morality. *International Journal of Science Education*, *28*(12), 1463–1488. https://doi.org/10.1080/09500690600708717

Sadler, T. D. & Zeidler, D. L. (2005). Patterns of informal reasoning in the context of socio-scientific decision making. *Journal of Research in Science Teaching*, *42*, 112–138. https://doi.org/10.1002/tea.20042

Sadler, T. D. (2011). Situating socioscientific issues in classrooms as a means of achieving goals of science education. In T. Sadler (Eds.), *Socio-scientific issues in the classroom: Teaching, learning and research* (pp. 1–9). Springer.

Sandoval, W. A., & Millwood, K. A. (2005). The quality of students' use of evidence in written scientific explanations. *Cognition and Instruction*, *23*, 23–55. https://doi.org/10.1207/s1532690xci2301_2

Serpell, R. (2011). Social responsibility as a dimension of intelligence, and as an educational goal: Insights from programmatic research in an African society. *Child Development Perspectives*, *5*(2), 126–133. https://doi.org/10.1111/j.1750-8606.2011.00167.x

Tal, T., Kali, Y., Magid, S., & Madhok, J. (2011). Enhancing the authenticity of a web-based module for teaching simple inheritance. In T. D. Sadler (Ed.), *Socio-scientific issues in the classroom: Teaching, learning and research* (pp. 11–38). Springer. https://doi.org/10.1007/978-94-007-1159-4_2

Taylor, M. J., McNicholas, C., Nicolay, C., Darzi, A., Bell, D., & Reed, J. E. (2014). Systematic review of the application of the plan-do-study-act method to improve quality in healthcare. *BMJ Quality & Safety*, *23*(4), 290–298. https://doi.org/10.1136/bmjqs-2013-001862

Topcu, M. S., & Genel, A. (2014). *Preservice science teachers' socioscientific issues-based teaching practice in real science classrooms* [Paper presentation]. National Association for Research in Science Teaching (NARST) Annual International Conference, Pittsburgh, PA, United States. https://www.researchgate.net/publication/320907932_The_classroom_observation_protocol_for_socioscientific_issue-based_instruction_development_and_implementation_of_a_new_research_tool

Topçu, S. T., Foulk, J. A., Sadler, T. D., Pitiporntapin, S., & Atabey, N. (2018). The classroom observation protocol for socioscientific issue-based instruction: development and implementation of a new research tool. *Research in Science & Technological Education*, *36*(3), 302–323. https://doi.org/10.1080/02635143.2017.1399353

Uskola, A., Maguregi, G., & Jimenez-Aleixandre, M. P. (2010). The use of criteria in argumentation and the construction of environmental concepts: A university case study. *International Journal of Science Education*, *32*(17), 2311–2333. https://doi.org/10.1080/09500690903501736

Walker, K. A., & Zeidler, D. L. (2007). Promoting discourse about socioscientific issues through scaffolded inquiry. *International Journal of Science Education*, *29*(11), 1387–1410.

Zeidler, D. L., Applebaum, S. M., & Sadler, T. D. (2011). Enacting a socioscientific issues classroom: Transformative transformations. In T. D. Sadler (Ed.), *Socioscientific issues in the classroom: Teaching, learning and research* (pp. 277–306). Springer. https://doi.org/10.1007/978-94-007-1159-4_16

Zeidler, D. L., & Nichols, B. H. (2009). Socio-scientific issues: Theory and practice. *Journal of Elementary Science Education*, *21*(2), 49–58. https://doi.org /10.1007/BF03173684

Zohar, A., & Nemet, F. (2002). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. *Journal of Research in Science Teaching*, *39*(1), 35–62. https://doi.org /10.1002/tea.10008