The Importance and Usefulness to Incorporating Argumentation in Science Education to Prepare Students to Interact with Science in their Daily Lives

Lauren Filippidis

Abstract: Argumentation is a language of science that promotes critical thinking and reasoning skills. While it is a vital form of discourse used within the scientific community, it is also essential in preparing students to interact with science in their daily lives. Incorporating argumentation skills into the science classroom holds a usefulness in preparing students to be able to engage in socio-scientific issues they will face and in promoting scientific literacy. Science educators becoming aware of the importance of including argumentation will benefit students by encouraging critical thinking, reasoning, and communication. It will give students the skills necessary to be able to engage in discussions about issues faced in their lives and back their discussion with evidence.

Introduction

The everyday person may not think they interact with science in their daily lives, especially those who have not pursued a career or higher education in STEM. What people, especially students, do not realize, however, is that every one of them interacts with science daily, even outside of the classroom. This interaction with science outside of the classroom includes a variety of contexts, from social to political. For example, almost every person has heard of climate change or an environmental crisis. That is a socio-scientific issue that most people have an opinion about, one way or another. Nonetheless, even though people hold strong opinions about socio-scientific issues such as climate change, I cannot guarantee that everyone is able to back their opinion with credible evidence and partake in an argument with peers about their stance through proper informal reasoning and critical thinking skills. That is why incorporating argumentative skills in science education is important.

Scientific argumentation is an important language of science. It has a usefulness to students both inside and outside of the classroom. Argumentation promotes skills that students will use in their daily lives. It is important for educators to understand these skills and become aware of including it in science education. Facing everyday issues affects every person and they need to be able to interact and interpret these issues. Argumentation is a means to becoming scientifically literate. According to the National Science Education Standards (1996), "Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions" (p. 22). Students being underprepared and lacking the skills to understand and participate in science in their daily lives when encountering issues begins with understanding and addressing what we know as science educators and incorporating argumentation into the classroom.

Argumentation in Science

Argumentation is a vital form of discourse in the scientific community. According to Erduran and Jiménez-Aleixandre (2008), argumentation plays a central role in the building of explanations, models, and theories in science. Scientists use arguments to relate the evidence they select to the claims they reach through use of warrants and backings (Erduran & Jiménez-Aleixandre, 2008). Argumentation is a language of science that provides the necessary skills that will allow students to think critically about an issue encountered in their lives and be able to take an informed stance. The role of argumentation is essential to scientific inquiry. Without this skill, students would be unable to propose explanations based on evidence or critique credibility of information in a source. It allows the ability to make a claim supported by evidence and reasoning.

Unlike arguments faced in daily life, scientific argumentation involves development, evaluation, and validation of scientific knowledge and knowledge construction (Faize et al., 2017). When people hear the term "arguing" they most likely think of it as a fight or disagreement. Proper argumentation is more than that and it can be utilized in daily life outside of the classroom. Scientific argumentation is not fighting, based on opinions only, or experienced only in the classroom. Scientific argumentation is making a claim supported by evidence, a way to explain findings justified with reasoning, and is encountered in everyday life through media, advertising, politics, the environment, etc. This breakdown is important for educators and students to understand, as it is more than just an opinion and can be experienced in numerous circumstances.

As a science educator, I believe argumentation skills need to be incorporated into the science classroom. It has many benefits in science education. These benefits include developing critical skills, prompting spirit of enquiry, enhancing conceptual understanding, and improving academic performance of students (Faize et al., 2017). In my encounters with students and young adolescents, they are underprepared to engage in science not only in the classroom but also in their daily lives. Students need to be taught how to back reasoning with evidence and how to take an educated stance on a position. Enhancing argumentation skills in the classroom can be done by leading by example as educators, by including more open discussions in class, and by incorporating more evidence-based labs. This inclusion in the classroom will benefit students and teach those skills.

Argumentation Interventions Promote Scientific Literacy

Student participation in argument develops communication skills, metacognitive awareness, critical thinking, an understanding of the culture and practice of science, and scientific literacy (Cavagnetto, 2010). It promotes the achievement of scientific literacy and students talking and writing science. Becoming scientifically literate represents the ability to use evidence and data to evaluate the quality of the information and arguments presented by science, the mass media, and to have the necessary scientific knowledge base to make informed decisions in life (Dragos & Mih, 2015). Arguments can be used to explore societal issues that influence science. These issues include moral, ethical, and political issues that provide authentic context for science

instruction (Cavagnetto, 2010). Students will not achieve this ability to interpret and criticize societal issues without the ability and knowledge to apply what is learned in the classroom to their everyday lives.

Argumentation Instructional Models in Socio-Scientific Contexts

Scientific argumentation is about preparing future citizens to make personal and collective decisions on socio-scientific issues (Dawson & Venville, 2009). Dawson and Venville (2009) describe socio-scientific issues as those that are "based on scientific concepts or problems, controversial in nature, discussed in public outlets and frequently subject to political and social influence" (p. 1422). Informal reasoning and argumentation are important in making decisions on issues faced. These issues are faced on an individual and societal stance. Argumentation skills in science education can be implemented individually or in a group setting. These skills can be used when science students share with others their scientific knowledge in a form of discourse to come to a group decision about a socio-scientific issue or an individual student can utilize argumentation skills to answer a question and justify their opinion (Dawson & Venville, 2009).

Generating an Argument is an instructional model that provides small groups of students practice in scientific argumentation in the classroom. Generating an Argument requires students to develop a claim that answers a research question based on a supplied data set (Sampson & Schleigh, 2013). Small groups of students make a claim that answers a research question based on available data. According to Sampson and Schleigh (2013), in this process groups create a tentative argument that provides this claim and the evidence that supports it, using a medium that can be viewed by others. Each group has an opportunity to share their ideas during an argumentation session. These sessions are designed to create a need for students to discuss the validity or acceptability of the various arguments based on the available information (Sampson & Schleigh, 2013). Students are able to refine their claims based on discussions and better describe the phenomenon they are investigating. Each student then writes a final argument to submit to their teacher. To conclude this instructional model, the teacher leads a whole-class reflective discussion and encourages students to consider what they learned about the content and nature of science (Sampson & Schleigh, 2013)., The Generate an Argument model allows students to participate in argumentation and allows the teacher to incorporate argumentative skills in relation to current phenomenon students face. This could be utilized with any phenomenon to fit the teacher's curriculum. For example, a unit on renewable energy. A teacher may utilize generate an argument to present students with data on renewable energy implications in society.

Research done in science education further supports the claim that students are underprepared to participate in science when it comes to real world issues. Wu and Tsai (2007) investigated the significance of science educators and school science instruction building a foundation for better informal reasoning and decision-making on socio-scientific issues. This study focused on high school learners' informal reasoning on the socio-scientific issue of nuclear energy. The study analyzed seventy-one grade ten students' informal reasoning about nuclear energy. An open-ended questionnaire was developed and used to collect qualitative and quantitative data.

Wu and Tsai (2007) found that high school students did not have the sufficient abilities to make connections between what they learned in the classroom and the socio-scientific issue they encountered. Almost one-quarter of the students in the study made their decision on nuclear power usage intuitively. This study also showed that the students who did make evidence-based decisions were significantly more oriented to change their information after reading a summary about the issue, without noting the credibility of the summary. This study shows that science educators need to pay more attention and learn more about teaching students to apply their knowledge learned in the classroom to taking a stance on or solving real-world problems.

Additional research also supports this claim. Dawson and Venville's (2009) research with high school students demonstrates the importance of argumentation in science education and the lack of discourse skills in students. They obtained data through interviews with ten 12-13 year olds, fourteen 14-15 year olds, and six 16-17 year olds. The aim of their research was to explore high-school students' argumentation and informal reasoning about biotechnology. The notion of scientific literacy was used as the basis of the theoretical framework to examine their data. Dawson and Venville (2009) found that most students used no data or only simple data to justify their claims. Overall, rational informal reasoning was expressed in about one-quarter of the students and the majority of students used intuitive and emotive informal reasoning rather than rationale to justify their viewpoint (Dawson & Venville, 2009). The students in the study lacked the discourse skills needed to make informed decisions and instead based decisions on feelings rather than reasoning to express their views on biotechnology.

Students' Needs in the Development of Scientific Literacy

Science education contributes to the development of the ability to understand the most effective way to use science in daily life and social responsibility (Dragos & Mih, 2015). Students need support in achieving scientific literacy through argumentation and encouragement to talk and write science. This support is achieved through classroom instruction. For example, this support and focus on engaging students in scientific argumentation will require teachers to place more emphasis on "how we know" in science (how new knowledge is generated and validated) in addition to "what we know" (theories, laws, concepts) (Sampson & Schleigh, 2013). This focus on learning to talk and write science can be achieved through certain instructional strategies to support the needs of students. Science teachers will need to implement instructional strategies that give students an opportunity to learn how to generate explanations from data, identify and judge the relevance or sufficiency of evidence, articulate and support an explanation in an argument, respond to questions or counterarguments, and revise a claim (or argument) based on the feedback they receive or in light of new evidence (Sampson & Schleigh, 2013).

Students must practice and participate in argumentation and other communication in the classroom, along with analyzing sources and practice critical reading of a text to determine credibility of information. Accomplishing these skills in the classroom will give students the necessary tools and abilities to then apply these skills to their life outside of the classroom. Students can utilize persuasion and argumentation to evaluate a socio-scientific issue and engage in discussion with others with

proper information and evidence to back their claim. Executing these skills first in the classroom will give students what they need to become active and responsible citizens through the development of the necessary knowledge and understanding of the problems faced by mankind (Dragos & Mih, 2015).

Argumentation is a form of discourse that needs to be appropriated by students and explicitly taught through suitable instruction, task structuring and modeling (Erduran & Jiménez-Aleixandre, 2008). Students' knowledge acquired in the science classroom can serve as tools for their informal reasoning and decision-making on controversial issues (Wu & Tsai, 2007). These issues include a variety of contexts such as climate change, politics, pollution, energy usage, biotechnology, and so on. Students will encounter these issues and need to be prepared to properly analyze them and defend their stance. Social media has become a major part of young adolescents' lives and information received through social media platforms is not always from a reliable source. It is vital to encourage argumentation in science education so students know when they are receiving credible information. Preparing students for this can be accomplished by including argumentation skills in the classroom. That can be done in different ways including instructional models such as generate an argument as mentioned earlier. Another way I have successfully incorporated practicing this skill in my experience with secondary science students is through discussions and labs. I begin instruction by posing questions and asking students what they think might happen in an experiment. Opening this type of dialogue and then completing an experiment where students can then back their discussions with evidence is one good way to incorporate argumentation practice into the classroom.

Conclusion

Scientific argumentation is one of the most important skills and should be strengthened by students, as students who are scientifically literate will be able to apply the knowledge learned to solve problems in everyday life (Jufrida et al., 2019). Incorporating argumentative discourse is vital in preparing students to achieve becoming scientifically literate which will lead to students having the ability and skills necessary to make evidence-based claims and determine credibility of sources. Scientists use arguments to relate the evidence they select to claims they reach through use of warrants and backings (Erduran & Jiménez-Aleixandre, 2008). Students have the right and responsibility to participate in science and properly examine information and research to make a claim and take a stance that is backed up by evidence. Argumentation in science education will provide students with the ability to approach issues in authentic and meaningful ways.

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About the Author

Lauren Filippidis received her Bachelor of Science from The Ohio State University in 2018. She recently earned her Master of Education in Secondary Education from the University of Toledo in Summer 2022. Lauren will be teaching high school Biology in the Columbus City school district beginning in the 2022-2023 school year.