

# Socializing Science Education Empowering Students Through the Use of Discourse and Argumentation of Socioscientific Issues

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**Abstract:** Science teaching must begin to accommodate the changing role that science and technology has in the modern world. Citizens have increased avenues in which science can be used in decision-making in their lives and teaching students only content knowledge is not enough to equip them with the critical skills they need. Science education must promote social justice by giving all students opportunities to learn the nature of science as it relates to socio-scientific issues and explore the different values that are embedded in scientific decision-making. Science education should not only address content, it should encourage discourse and practice of science in order to empower students with skills to become responsible participants in their personal, professional and civic lives.

## Introduction

Take out a pencil and paper. Draw a scientist. What is in your picture? What is your scientist doing? If you drew a white guy with crazy hair working alone in a laboratory creating various concoctions or something dangerous, you have drawn the same image as the majority of students who have participated in this activity since 1957. The Draw-a-Scientist Test (DAST) activity has been researched with school aged children to get a sense of their perceptions of science and these results have guided reform of science education (Farland-Smith, 2012). In one study of the DAST in a 4th grade class half of the students drew something dangerous, such as bombs and poisons. One student drew their scientist holding a test tube with a caption stating that he will destroy the world (Brooks, 2012). According to Farland-Smith (2012), students' perceptions about scientists affect their attitudes about science in the classroom. Further, if students cannot relate to those who use science, they often become disengaged from science. The language and practices used in science classrooms can also be alienating. Students struggle to make connections with science content and how an ordinary person can use science. Additionally, students commonly see science as dangerous and capable of posing threats in society (Brooks, 2012). Based upon the above research from Farland-Smith (2012) and Brooks (2012) it can be surmised that students are confused about science, and this confusion is creating critical problems in society.

As science knowledge has evolved and the use of science and technology has increased exponentially, citizens are faced with numerous science-based decisions as consumers, voters, professionals, and participants in society. In order for students to make informed decisions on issues such as climate change, water and air quality, agriculture, public health and medicine, and energy use, adequate understanding is key. Students today will be affected most by the predictions made by scientists for the future. Science is not just for future scientists. Science affects us all, and science education must address that. Science is more than just content. It is a tool that can be used to explain that natural world, make predictions and create solutions. Students who do not connect with science content are likely unable to make informed decisions about science in their lives. Hence, science instruction must begin to accommodate the changes from the use of science and technology. Education should not only address content, but allow for discourse and practice of science in order to empower students with skills to become responsible participants in their personal, professional and civic lives.

## Social Process of Science

The creation and use of scientific knowledge is a social process. How we view and conduct science has changed drastically over time. According to Morris (2013), the use of science and technology for mass purposes increased greatly during the "industrial revolution or industrial society" (p. 1144). However, we have now evolved into a post-industrial society, one dominated by science and technology. The conduct of science currently affects our environment and populations at much greater rates than the pre-industrial and industrial societies, and citizens have more avenues in which they can share a voice in the conduct of science. As voters, consumers, professionals, and participants in society we have a much greater control of the decisions we make that affect the well-being of all components of society. As we have entered an information age, students and citizens have access to scientific knowledge, both accurate and inaccurate, at exponentially greater rates than past eras. Due to the changing nature of the world, and the different contexts in which science is used and learned, students must be equipped with the skills in order to understand their place in society as it relates to science.

In the creation of scientific knowledge, scientists have different experiences, abilities and purposes that help mold conclusions drawn by scientists. Although many scientists have the ultimate goal of being as neutral as possible, sometimes it is not achievable. This socially constructed scientific knowledge, either as theory or as empirical evidence, is used for a social purpose. This scientific knowledge may be used by other scientists, policy makers, engineers, citizens, or consumers to form biased conclusions or to be used to support the use of a new technology (Kolsto, 2001). Unfortunately, bias can lead to misuse of scientific knowledge, which can translate into the development of

misconceptions. All of these elements, which include the subjective, tentative, and social aspects of science constitute the Nature of Science (NOS).

Common misconceptions of the NOS offer learners and science educators an opportunity to interact with science in an authentic way. Events from the scientific community impact what occurs in the science classroom and to address the impact of socially constructed science, teachers can use the concept of socio-scientific issues (SSIs). SSIs are “science-related, social, open-ended dilemmas” (Khishfe, 2014, p. 976) that often pose problems in society and spur controversy in search for solutions. Current SSIs involve, but are not limited to, climate change, food and agricultural concerns, public health, and resource use. Through the study of SSIs, students can accept and understand the NOS.

### **Science for Social Justice**

In coming to an understanding of the social process of science and SSIs, students have a right to be equipped with skills to transform these problems. A current trend in science education is promotion of scientific literacy, which involves equipping students with science knowledge to be able to be productive members in society as adults. However, the ability to use scientific literacy in adulthood varies when students have limited access to opportunities in which to utilize science or have little knowledge of the various contexts in which science is used. Therefore, science teaching should aim to create social justice by promoting equal access to science not only through scientific literacy but also critical literacy. Students should be empowered with the skills of science including content knowledge, discourse, and practice in order to be able to transform their own lives. With current SSIs that marginalize specific groups, and with others who hold more power in decision-making, it is essential that students be equipped with the skills to understand and act upon that. Barton and Upadhyay (2010) give three assumptions that need to be accepted in science education for social justice: “...having the opportunity to learn science as content knowledge, discourse, and practice is a civil right; teaching and learning science involves critical activism and citizenship; and the goals of science literacy involve personal, social and economic empowerment” (p. 5). Science teaching, therefore, is not only the mastery of content knowledge. The NOS and current SSIs make it imperative that science should evolve to include discourse and practice.

Science teaching for social justice should aim to develop students with critical science agency. This is an element created in a model for Democratic Science Pedagogy by Basu and Barton (2010). Critical science agency is the ability of students to be central in knowing and doing science. Many students already have a strong science knowledge base. This knowledge should be used as a stepping stone to develop their own learning and projects with guidance, not direct instruction, from the teacher (Basu & Barton, 2010). A key element for empowering students with critical science agency is through allowing discourse and argumentation in the classroom. This ensures that students’ voices, experiences, and ideas are valued in relation to science content and a dialogue is formed to develop solutions to SSIs.

### **Discourse and Argumentation**

Effective science teaching is known for engaging students in hands-on labs, simulations, experiments, and investigations which are all methods of inquiry. These methods are crucial for helping students to construct their own understandings of science content. There is also a push for engaging students in argumentation. An exact definition of argumentation is lacking in science literature, however “...it is commonly defined as an assertion or a claim and its accompanying justification” (Khishfe, 2014, p. 976). Argumentation also often involves constructing counterarguments. Therefore, when students engage in scientific argumentation, they are taking observations from the process of inquiry and using them to explain a science concept. However, given the NOS and a goal of science teaching for social justice, these claims should be made about SSIs in order to give students the ability to form their own opinions. During this process, the many contexts-including social, political, and ethical-embedded in science will be attached in students’ arguments. However, students should not first be presented with these contexts in the argumentation stage of teaching. Student discourse should be embedded within all stages of science teaching in order for students to be familiarized with all contexts of science.

Discourses can be defined by “Gee (1996) as ways of knowing, doing, talking, interacting, valuing, reading, writing, and representing oneself that are ‘always and everywhere social,’ produced and reproduced in social and cultural practices” (Barton & Tan, 2009, p. 51). Academic discourses vary across contents and it is commonly accepted that it is important to make explicit each discourse in order to become proficient in that content. However, academic discourses vary greatly from the cultural and social discourses from students’ personal lives. This can make academics difficult and alienating for many students. However, Barton and Tan (2009) argue that students’ discourses should be incorporated along with academic discourses to create ‘hybrid spaces’ and should be used when studying critical problems in students’ lives.

Barton and Tan (2009) conducted a study in an urban 6th grade classroom. A six-week unit about food and nutrition was taught in which students were given opportunities to incorporate their cultural discourses in order to better understand the science content connected

to food and nutrition and the issues faced in being able to use this content knowledge when making decisions about food. Examples of discourses included family discourses when students were asked to interview family members about a favorite recipe and share it with the class. Students not only shared the recipe, but also analyzed how funds of knowledge about food come from mothers; how there is shared responsibility in decision making surrounding food; and how there are challenges to obtaining access to nutritious or adequate supplies of food. Students also shared community, peer, and popular culture discourses in similar ways to analyze how science content could be used in the students' lives and to solve problems. Students were able to realize that students already had a wealth of knowledge about food and nutrition and were able to connect that with the shared wealth of academic knowledge from the teacher. Science was seen as a tool to understand the students' lives and not a directive from the teacher to understand expert authority. Not only were democratic principles met in the classroom, but every student in each of the five participating classes completed the final service project with a passing grade. This is in stark contrast to the norm, where many students do not complete projects and receive failing grades (Barton & Tan, 2009). Creating hybrid spaces is also essential for developing students with critical science agency, helping students to understand social contexts embedded in science, and scaffolding content so that students are prepared to participate in effective and meaningful argumentation.

One part of science discourse that teachers can share with students is argumentation. This skill is essential for students to develop their stances on SSIs that will transfer to social, professional and political discourses outside of school. In argumentation, students have the opportunity to use empirical evidence constructed from inquiry and apply it to the social contexts of science. Students can share their experiences and opinions, however also acknowledge the differences between scientific empirical evidence and epistemic justifications. Khishfe (2014) researched how argumentation instruction affects students' abilities to reason about SSIs. In this study, students participated in an eight-week water safety unit. All participating students were given explicit argumentation instruction, but some treatment classes were also given explicit NOS instruction. NOS instruction involved exploring that science is tentative, empirical and subjective and argumentation instruction allowed students to discern between empirical science evidence and epistemic justification. For example, students made claims about the fluoridation of water. A student opposed the fluoridation of water because scientific evidence shows that it can cause cancer, it violated people's rights to safe water, and fluoride does not have approval from the FDA. Another student supported fluoridation because scientific evidence supported that fluoride can prevent dental disease and also is an inexpensive way to promote public dental health. Each argument was justified with scientific and epistemic reasons, students were able to discern between each, and students could engage in rebuttals and reconstruct their stances. Results showed that all students' understandings of the NOS improved at the end of the unit and classes that received explicit NOS instruction had significantly greater levels of both NOS and argumentation skills. Allowing students to explore the NOS in context of SSIs and receiving explicit argumentation instruction can be effective at developing students with abilities to engage in scientific discourse.

### **Criticism of SSI**

Critics of teaching SSIs argue that controversy should be omitted from the classroom (Hodson, 2003). Teachers should remain as neutral as possible to avoid indoctrination because a mastery of content will automatically allow students to apply content to decisions in students' personal lives. However, Hodson (2003) points out that omitting the political and social values embedded in science is influencing students in a particular direction in itself. Leaving out these contexts is also contradictory to the NOS. Students have a right to explore science in the ways that it is, and will be, presented to them in their lives. This stance does impose values upon students, however these values are formed with the best interest of the students by equipping them with knowledge of how to be responsible and empowered democratic citizens (Hodson, 2003). Not only that, but an increase in content knowledge has not been proven to increase the ability to use science in its contexts.

Previous studies mentioned (Barton & Tan, 2009; Khishfe, 2014) in this article have supported how teaching SSIs can improve student content outcomes. In addition, Sadler and Donnelly (2006) specifically conducted a study to explore if there is a correlation between content knowledge and the ability to effectively argue about SSIs. Students were surveyed and interviewed about genetic engineering. The majority of students rarely used genetics content knowledge in reasoning. Less than 10% of students referred to genetics content in their responses and those responses gave very general references to genetics content. Interviews also showed students referring to science fiction and the media to explain their stances. These results prove concerns about application of content knowledge. Science must be taught in current social contexts so students can develop the critical skills they need.

### **Conclusion**

Students have a right to understand and act upon issues that affect them today and to be equipped with skills in order to understand issues they have yet to face. Science teaching must incorporate the changing NOS in the modern world. Science content knowledge is not enough

for the students of today. They must have opportunities to engage in discourse and exploration of SSIs. Students can become engaged and familiarized with science by incorporating non-academic discourses from students' lives, which can be used to enhance the teaching of scientific discourse and argumentation. These discourses can guide students to understand multiple viewpoints and contexts of critical SSIs in order to be empowered to transform science problems in their lives. Through these practices, content expectations can be met and students can develop as informed and empowered citizens.

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