Stories in the Science Classroom: Supporting a Humanistic View of Scientific Literacy

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Providing Direction

"Keep what's true in front of you…you won't get lost that way" (Wagamese, 2016, p. 74).

"Science…must be taught as a humanity" (Aoki, 2004, p. 199).

These two quotes effectively provide a lens through which to examine the current state of science education and the teaching of scientific literacy. The COVID-19 pandemic exposed several chinks in the armour of science teaching. Indeed, developing scientific literacy is a fundamental goal of many educational jurisdictions. As one example, in the province of Alberta, the curriculum document, (known as the Program of Studies) for secondary science stated: "The secondary science program is guided by the vision that all students have the opportunity to develop scientific literacy" (Alberta Education, 2014, p. 1). Roberts and Bybee (2014) supported this by stating that the development of scientific literacy in students is an inextricably linked goal of the education system. Despite an educational focus on scientific literacy around the world many individuals discarded the knowledge learned in science class in favour of alternative ways of knowing. These included things like political leanings (Weisel, 2021), belief in conspiracy theories (Miller, 2020), and level of education (Albrecht, 2022), indicating that perhaps you don't need a specific science education but just a general higher level of education to be able to make better public health decisions. It was clear that conventional science education was not sufficient for individuals to understand the "truth", (drawing on their scientific literacy) and many were getting lost as a result.

Aoki (2004, referencing Smith, 1991) highlighted that many university students felt their pre-university science education did not adequately prepare them for post-secondary studies. This, in conjunction with the evidence from the COVID-19 pandemic make it clear that there is a clear need to change science instruction in K-12. With this in mind, Aoki (2004) asserted that "science must be taught as a humanity" (p. 199), marking a fundamental shift from conventional K-12 science education. To explore this shift, the concepts of the Nature of Science (NoS) and socio-scientific issues (SSIs) (Zeidler et al., 2005) will be employed as a theoretical framework. This approach aims to dismantle barriers to science education for students who do not fit the stereotypical image of a scientist (Barman, 1999) while also showcasing the extensive range of opportunities available within the broad field of science, and to truly tell the story(ies) of science. In so doing, scientific literacy can be attainable by all, helping individuals be more prepared for engaging in science within a societal context.

Scientific Literacy: Proposing an Alternative Translation

Defining scientific literacy remains a challenging endeavour despite its critical importance and relevance to science education. Norris et al. (2014) conducted a comprehensive review of 62 papers on the subject, revealing both commonalities and significant variability in the definitions of scientific literacy. These variations are often influenced by the stated objectives of scientific literacy and the political and moral justifications underlying these objectives. Norris et al. (2014) described scientific literacy as a programmatic concept, indicating that its definition is inherently contextual, shaped by specific objectives, values, and moral perspectives within a given context. This contextual nature is particularly relevant in an educational landscape where STEM (Science, Technology, Engineering, Mathematics) education is predominant. STEM education, driven by career-focused and economic motivations, manifests differently across various educational settings (McComas & Burgin, 2020). McComas and Burgin (2020) critique STEM education by highlighting these differences in understanding and practice. Some educators advocate for the separation of the four components, while others emphasize the need for a balanced integration of science, technology, engineering, and mathematics.

Given the inherent variability in the definitions of STEM education, it is unsurprising that there is also divergence regarding the concept of scientific literacy. If the primary mode of delivering science education is through a STEM approach, and there is no consensus on what constitutes that approach, how can there be agreement on the resultant outcome—scientific literacy? If scientific literacy is indeed a programmatic concept, as suggested by Norris et al. (2014), then each unique context in which scientific literacy is a learning outcome may yield different interpretations and definitions. Moving forward, the goal should be to establish a unified—or at the very least, a more encompassing—definition of scientific literacy. I will examine two conceptual understandings below, and outline how one can be used to create this more unified definition.

Visions: Two Conceptual Understandings of Scientific Literacy

Roberts (2007) and Roberts and Bybee (2014) outlined two distinct forms of science-related disciplinary literacy, referred to as Visions. These Visions, derived from trends in science education literature, represent differing conceptions of science-related disciplinary literacy. To further distinguish these two perspectives, they are labelled Science Literacy (Vision I) and Scientific Literacy (Vision II). This immediately suggests a distinction between knowledge and action. The term "scientific" implies the active practice (action) of science (knowledge). It is intriguing that the term "Vision" is preferred in this context, as it seems to elevate these concepts beyond the traditional boundaries of science-related disciplinary literacy. As Visions, they are more holistic and comprehensive, free from rigid rules and constraints.

In summary, Vision I (Science Literacy) focuses on the knowledge, methods, and skills taught in science classrooms, derived from the extensive body of scientific information. Roberts and Bybee (2014) described it as “general familiarity and fluency within the discipline, based on mastering a sampling of the language, products, processes, and traditions of science itself” (p. 546). Essentially, students involved in Vision I learning acquire knowledge and skills from the existing scientific corpus. This is appropriate for students entering STEM based careers who need significant knowledge background and skills in order to complete further study.

Vision II (Scientific Literacy) is action-oriented, building on what is understood from Vision I for scientifically informed citizenship. Roberts and Bybee (2014) stated that it involves “learning how science fits appropriately with such personal and societal perspectives for a more complete grasp of the issues” (p. 546). Vision II aligns with socio-scientific issues (SSI) education (discussed in next section), emphasizing the need for citizens to engage with SSIs, and engage in the exploration of ethics, diverse viewpoints, consequences, and the interdisciplinary nature of science. This provides a more complete scientific literacy for those engaged in this type of learning, thus preparing them for productive decision making in the future.

Humanistic Scientific Literacy: The Alternative Translation

One way to achieve these goals in Vision II comes from Aikenhead (2006) who advocated for the teaching of a humanistic perspective of science. He situated this perspective firmly in a societal context, carried out by a community of scientists, with members of society using, making decisions about, and participating in science. One way to achieve this goal of humanistic science is through the use of socio-scientific issues (SSIs) in teaching. Zeidler et al. (2002) defined SSIs as the teaching of how society and technology are connected to the work of science (or content knowledge of science), with added dimensions of ethics, morality, and character development (including empathy, self awareness, integrity) in the scientific process. These added dimensions distinguish it from STS (Science, Technology, Society), teaching, which simply focuses on the connections (Zeidler et al., 2005).

An illustrative example of socio-scientific issues (SSI) teaching is the topic of COVID-19 vaccination. Contemporary public health issues encompass numerous moral, ethical, and character development components that accompany the scientific discourse. This topic provides an opportunity to educate students about the immune system, the technological and biological aspects of vaccines, and the historical development and rigorous testing and approval processes that vaccines undergo. Furthermore, it allows for a discussion on herd immunity, emphasizing the moral and ethical responsibilities individuals hold in contributing to population health. While understanding the scientific knowledge is important, the integration of moral and ethical considerations significantly enriches the discussion. It is evident that decisions regarding individual vaccine uptake extend beyond mere comprehension of biology and technology; they also involve a complex interaction of other important considerations. This humanistic perspective on scientific literacy provides a holistic view of any science topic and an alternative translation to traditional definitions of scientific literacy that rely heavily on knowledge and skills When teaching is delivered through the lens of SSIs, people who lack a complete understanding of science literacy can nonetheless actively participate and make judgements regarding the socio-scientific issue (Solomon & Aikenhead, 1994).

Nature of Science as a Pedagogical Approach

With an alternative translation of scientific literacy in place, the next step becomes to enact pedagogy that supports this outcome, such as the Nature of Science (NoS). Allchin (2013) broadly defined the Nature of Science (NoS) as “the whole of science” (p. 4). This definition encompasses both the conceptual and social aspects of science, alongside its experimental positivist elements (Dai et al., 2021). Lederman (2006) provided a more specific perspective, stating that NoS is “the epistemology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge or the development of scientific knowledge” (p. 303). In other words, to understand the “whole” of science (Allchin, 2013), one must comprehend how scientific information is generated, as well as the beliefs regarding the nature of scientific knowledge—its tentative, subjective, and creative aspects (Michel & Neumann, 2016). The term “whole” science (Allchin, 2013) underscores the importance of understanding the origins of the knowledge we acquire, the methods employed to obtain that knowledge, and the social implications that knowledge carries.

There is a clear relationship between SSIs and NoS. If NoS is the "whole of science" (Allchin 2013), then SSIs with its content knowledge, connections to technology and society, and its moral and ethical components is encompassed within the NoS framework. The choice for NoS ensures that during the teaching of science, all components of any science content in curricula are included, not simply the memorization of scientific facts. In order to examine the whole, the use of science stories is an effective pedagogical tool that has been used effectively in many contexts.

Science as a Humanity: Stories in the Science Classroom

Klassen and Klassen (2014) stated that stories offer context and proposed five types of context that illustrate how stories, such as SSIs, can provide a more complete comprehension of the information being taught. Stories have characters, actions taken by those characters, events or situations to which characters respond, and causality between actions and results. ElShafie (2018) also included the need for a specific obstacle to overcome and stakes (something at risk for the characters) to compel action. In the case of a science story, Padian (2018) asserted that there needs to be a degree of testability in a science story to give the authentic genuine experience. The following are identified benefits of using story in the science classroom:

- They connect content ideas together, from the science class and outside the science class (Engel et al., 2018).
- Students taught through story reported improved learning experiences (Rodrigo et al., 2019).
- They make science meaningful (ElShafie, 2018).
- They provide students tools to understand social situations (Hadzigeorgiou & Schulz, 2019).

These benefits clearly demonstrate a direct connection to SSIs, and humanistic scientific literacy. In this context, stories fall under the larger narrative provided by SSIs. The issues that are addressed in SSIs (e.g., COVID-19 vaccination) are taught effectively through the use of story. By bringing in this humanity-based method of teaching, the goals of reaching more students, specifically those non-STEM students, becomes a reality.

Scientific literacy is an essential skill to have in a modern society. When considering persistent problems such as climate change, or unexpected events such as a global pandemic, there is a need to engage in scientific, humanistic and productive decision making. By using a pedagogical framework of Nature of Science, and using stories as a specific teaching tool, we can increase humanistic scientific literacy and improve decision making in the general population.

Conclusion

The notion of humanistic scientific literacy and its corresponding theory and practice provided by this discussion establishes a framework to examine contemporary public health issues in science curricula in K-12 contexts. Next steps for this researcher include examining the use of an SSI narrative in biological sciences teaching to improve understanding of contemporary public health issues through the use of story. By making these connections, the hope would be to create learning opportunities that result in students making sound public health decisions ("what's true" from Wagamese, 2016) in a variety of contexts as humanistic and scientifically literate adults. In some cases, such as with COVID-19, this could be an issue of life or death (Ocobock & Lynn, 2020).

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