The Importance of Scientific Literacy in Modern Classrooms

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Abstract: To thrive in modern classrooms, students must be equipped with scientific literacy skills that enable them to understand, evaluate, and communicate scientific information effectively. The internet and digital resources present a unique challenge, as not all online information is scientifically accurate or unbiased. This article aims to demonstrate how the internet and digital resources contribute to misinformation and disinformation in the classroom. It will also highlight the benefits of increased scientific literacy for students and explore various strategies educators can use to enhance these skills. The primary goal of this research is to identify effective methods to boost students' scientific literacy and overall success.

Introduction

> *In Mr. Trussel's biology class students are assigned different fertility technologies, such as IVF, preimplantation diagnosis, CRISPR, and gamete cryopreservation, and then are asked to create a presentation based on their findings. Students are excited to begin research but run into a big problem, how do they know if a source is scientifically accurate and unbiased? Students feel conflicted as they find evidence they would like to use for their research only to discover contradicting evidence that seems equally credible. This idea stumps Mr.Trussell and he begins to contemplate how to solve this issue. With the emergence of personal electronic devices, AI, and the internet, students are granted access to countless amounts of information in an instant. This novel leap in access however can be a double-edged sword, as students' access to information is significantly greater than what it was, but not all of what they find is scientifically accurate and unbiased. Mr. Trussel thinks back to his pre-internet classrooms, where access to information was largely governed by educators and school resources such as textbooks, academic articles, library books, and other modalities, which were generally accurate. Most of the students in pre-internet classes had access to information that was curated by educators or reputable institutions such as libraries, but the classroom in the digital age faces a dilemma. "How can I ensure the accuracy of information my students find from online resources?" Mr. Trussel thinks to himself.*

In this article, I will describe the role of modern educators in guiding students through the landscape of information through the teaching and implementation of scientific literacy. Scientific literacy is a general understanding of science, scientific frameworks, and the ability to accurately convey scientific ideas. Some examples of these concepts are understanding the scientific method, cell theory, evolution, etc. I believe that science educators must accurately instruct students on scientific literacy in today's increasingly digital age.

Definitions

Scientific literacy is the ability to understand, evaluate, and communicate scientific ideas effectively. In most dictionaries, literacy is simply the quality or state of being literate (Merriam-Webster, n.d.) but scientific literacy is different as it requires a fundamental understanding of scientific processes, figures, and ideas. In science classrooms, students are seldom asked to not only understand texts but also to communicate their findings or research which also requires these fundamental understandings of science. One final piece that I included in this definition of scientific literacy is the ability to evaluate scientific information. I chose to include this to formally address the large body of misinformation, false or inaccurate information, and disinformation, false information deliberately intended to mislead, prevalent in the digital age (American Psychological Association, 2022).

Problems with Digital Media and the Internet

The primary issue regarding internet resources and digital media is a lack of regulation. While an obvious solution would be to regulate information, this is a nearly impossible and fruitless endeavor, not to mention these practices would violate First Amendment rights. The internet and digital media can be excellent and affordable tools for almost all scenarios but come at the cost of personal and corporate agendas. "The most egregious cases of scientific misinformation are typically deliberate efforts by monied interests or ideologues" (Allchin 2023, p. 266). Unfortunately, the free and open access to the internet lends itself to less than scientific ideas that can be presented as such for monetary gain and personal interest. Companies and other organizations often use or fund scientific studies that support their positions and in turn, present biased or falsified information to support their opinions.

Another issue with the information on the internet is that not everyone who claims to be an expert on a certain topic is an expert on that topic, and it can be difficult to find credentials or indicators that an individual is qualified to speak on certain issues. In a study that evaluated students' abilities to determine the credibility of online information, it was found that students from all grade levels struggled to accurately verify the credibility of sources, claims, and evidence (McGrew et al. 2018).

One final issue that needs to be addressed is the self-affirming nature of internet information. This phenomenon is commonly called confirmation bias, meaning people plan to find, support, and believe information that aligns with their preconceived ideas. As educators, this should be one of the alarming aspects of these resources as it can lead to a lack of critical thinking and alternative viewpoints. The internet is an invaluable resource in the classroom but educators and students need to be aware of these looming issues. Without these issues being properly addressed they will remain a problem in education and scientific discussion.

The Benefits of Scientific Literacy

In modern classrooms, scientific literacy is an essential skill that can help students understand and evaluate scientific materials. A 2018 study that looked at how well students could evaluate online scientific information found that most students were

not skilled at locating, understanding, or assessing the credibility of scientific information (Foranzi 2018). This is one of many studies that communicate this common idea; students typically do not have the scientific literacy skills that are needed in the modern classroom. One benefit of scientific literacy is it seems to help students distinguish between real and false information "A moderate and negative relationship was also observed between scientific reasoning and epistemologically unfounded beliefs. We proposed that the lower the level of scientific reasoning, the higher the tendency to succumb to epistemologically unfounded beliefs" (Synak et al. 2024, p. 169). I found this study particularly interesting because it looked at the correlation between the scientific literacy rates of students and their beliefs on unscientific ideas. One final benefit of scientific literacy is that it is correlated with cognitive learning outcomes (Mufida et al. 2023). In this study, students were subjected to inquiry-based models that were created to increase their scientific literacy and were then given tests that measured cognitive learning outcomes before and after this training, and it was found that the cognitive learning outcome scores were greatly improved. Scientific literacy has the potential to increase academic outcomes and students' ability to discern between scientific literature and misinformation and disinformation.

How to Teach Scientific Literacy

One potential way to increase students' scientific literacy would be to introduce scientific concepts at a younger age. Most forms of literacy are taught in the early years of a child's education as they are seen as a fundamental basis for finding and retaining information. Research has shown that learning experiences that are implemented for students in sixth-grade classrooms that emphasize critical thinking and scientific literacy contribute to increased levels of both (Viera & Tenreiro-Viera 2016). In this study, these lessons had an increased focus on questioning and debate, such as asking students to reflect on their ideas, debating conflicting ideas, and determining the credibility of claims. Encouraging these forms of thought at an early age is an effective way to promote scientific literacy by including scientific materials and scientific literacy.

Another possible solution to increase the scientific literacy of students would be to include students in real-world scientific research. This practice would give students hands-on experience with research and help familiarize them with these concepts and ideas. One such way to expose students to real-world applications is through research service-learning or RSL, which is when students engage in research in a service-learning context (Reynold & Adhern-Dodson 2010). The general approach to this practice starts by introducing a relevant community-centered project that can reasonably be completed by students.

In the 2010 study the authors focused on environmental-based projects such as monitoring populations and mapping invasive species. One method is to design assignments for students that encourage research and reflection on the current project as well as possible projects for the future. Another method mentioned in this study is determining what students need to learn in order to complete this project and achieve their learning goals. This practice can be very beneficial to help students increase their scientific literacy because it first allows teachers to properly address

misconceptions and flaws in students' thinking through the monitoring of their assignments. This practice also can help to increase scientific literacy by exposing students to real-world scientific practices and research, which can often be missing in traditional science classrooms. Although this practice requires extensive planning and collaboration, I believe that it can be used as a powerful tool to promote scientific literacy in classrooms.

One final study that I believe to be insightful looked at how post-test scores compared between middle school students who participated in online collaboration and students who received face-to-face instruction. This study from Wendt & Rockinson-Szapkiw (2014) compared the pre-test and post-test scores of these two groups of students using Misconceptions-Oriented Standards-Based Assessment Resources for Teachers, or MOSART, assessments that place a focus on addressing and testing for common science misconceptions that students may have. Unsurprisingly students who participated in the face-to-face collaborative groups demonstrated fewer misconceptions than those in the online collaborative group. I believe this article highlights the idea that teacher knowledge of misconceptions and in-class discussion is beneficial in eliminating scientific falsehoods and misconceptions for younger students. This article also mentioned that in these online collaboration groups, students often receive delayed feedback from teachers which can lead to them believing wrong ideas, as they are not immediately addressed like they are in traditional classrooms.

These unaddressed misconceptions can be harmful as students could communicate with each other online leading to more students having these false or misconstrued beliefs. Teacher knowledge of misconceptions and in-class discussion is essential for younger students because it allows their misconceptions and preconceived ideas to be addressed and corrected in real-time. For this, I believe it would be useful to provide primary and middle school teachers training on addressing scientific misconceptions and in-class collaboration, in order to eliminate scientific misconceptions for these students.

Conclusion

In conclusion, the digital age has brought both unprecedented access to information and significant challenges in ensuring the scientific accuracy of that information in classrooms. As demonstrated, students often struggle to discern credible scientific sources from misinformation and disinformation prevalent on the internet. Enhancing scientific literacy is essential in equipping students with the skills needed to navigate this complex landscape. Scientific literacy not only enables students to understand and evaluate scientific information but also fosters critical thinking and helps them avoid unfounded beliefs. Educators play a crucial role in this process by creating lessons that focus on debate, questioning, and reflection at an early age, and creating research-based service-learning projects that are designed to promote scientific literacy skills in their students. Ultimately, by prioritizing scientific literacy, we can better prepare students for a world where the ability to critically assess information is more important than ever. Increased focus on scientific literacy will lead to more informed individuals capable of making well-reasoned decisions in both

their personal and professional lives and contribute to a more knowledgeable and rational society.

References

Allchin, D. (2022). Ten competencies for the science misinformation crisis. *Science Education, 107*(2), 261–274. https://doi.org/10.1002/sce.21746

American Psychological Association. (2022, July). Misinformation and disinformation. *American Psychological Association.* https://www.apa.org/topics/journalism-facts/misinformation-disinformation#:~:text=Misinformation%20is%20false%20or%20inaccurate,mislead%E2%80%94intentionally%20misstating%20the%20facts.

Forzani, E. (2018). How well can students evaluate online science information? contributions of prior knowledge, gender, socioeconomic status, and offline reading ability. *Reading Research Quarterly, 53*(4), 385–390. https://doi.org/10.1002/rrq.218

McGrew, S., Breakstone, J., Ortega, T., Smith, M., & Wineburg, S. (2018). Can students evaluate online sources? learning from assessments of civic online reasoning. *Theory and Research in Social Education, 46*(2), 165–193. https://doi.org/10.1080/00933104.2017.1416320

Merriam-Webster. (n.d.). Literacy definition & meaning. *Merriam-Webster.* https://www.merriam-webster.com/dictionary/literacy

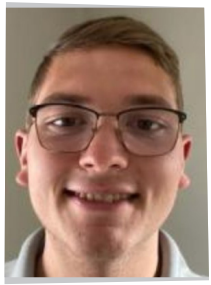
Mufida, N. C., Ibrohim, I., & Gofur, A. (2023). Science literacy and Cognitive Learning Outcomes in the implementation of guided inquiry learning model. *The 5th International Conference on Mathematics and Science Education (ICoMSE) 2021: Science and Mathematics Education Research: Current Challenges and Opportunities*. https://doi.org/10.1063/5.0112989

Reynolds, J. A., & Ahern-Dodson, J. (2010). Promoting Science Literacy Through Research Service-Learning--an Emerging Pedagogy With Significant Benefits for Students, Faculty, Universities, and Communities. *Journal of College Science Teaching, 39*(6), 24–29.

Synak, N., Šabíková, N., & Masaryk, R. (2022). Correlations among high school students' beliefs about conspiracy, authoritarianism, and Scientific Literacy. *Science and Education, 33*(1), 159–174. https://doi.org/10.1007/s11191-022-00380-w

Vieira, R. M., & Tenreiro-Vieira, C. (2014). Fostering Scientific Literacy and critical thinking in elementary science education. *International Journal of Science and Mathematics Education, 14*(4), 659–680. https://doi.org/10.1007/s10763-014-9605-2

Wendt, J. L., & Rockinson-Szapkiw, A. (2014). The effect of online collaboration on Middle School Student Science Misconceptions as an aspect of science literacy. *Journal of Research in Science Teaching, 51*(9), 1103–1118. https://doi.org/10.1002/tea.21169



About the Author

Sam Graham is a Licensure and Master Program, LAMP, student at the University of Toledo. He received a bachelor's degree in university studies with a focus on biology and is currently pursuing a master's degree education as well as licensure in AYA science. He has a passion for teaching all life science and is particularly excited in the field of genetics and biotechnologies.