International Journal of Didactical Studies
Volume 4, Issue 1, 2023
https://doi.org/10.33902/ijods.202320382

Conceptual Article

Scientific literacy as part of the science-for-all movement

Emilio Landolfi

University of the Fraser Valley, Canada

This paper will focus on scientific literacy as part of the 'science for all movement.' The work reviews how the curriculum has often catered only to those hoping to pursue careers in science and how a significant group of the population remain incapable of making educated, informed choices on science-related issues and how these issues impact their everyday lives. A historical examination of illiteracy in science will be provided, along with how the 'science for all' movement has attempted to respond to the need for increasing scientific literacy amongst the masses. The work will then explore how the 'science for all' movement relates to the larger field of 'curriculum studies' by examining how both positions emphasize becoming more critical, extending students' range of perceptions, and broadening students' perspective of the world around them.

Keywords: Scientific literacy, Science for all, Science education

Article History: Submitted 26 January 2022; Revised 27 February 2023; Published online 29 March 2023

1. Introduction

An overwhelming majority of today's adult population have little or no knowledge of how science impacts their daily lives (Kazempour, 2014). Citizens are exposed to rapid advances in science and technology. Yet so many people are often left feeling afraid or intimidated by the very innovations which have been designed to simplify their existence. Science literacy, as defined by the Organization for Economic Co-operation and Development [OECD], requires knowledge of key science concepts and the understanding of science processes which facilitates one's ability to make informed decisions on science-related issues which impact their lives (OECD, 2017). Glick et al (2021) assert that the problem of scientific illiteracy stems mainly from a general fear of science which can usually be traced back to a person's negative experiences with science in school. Consequently, North Americans have a long history of illiteracy in science, and the problem is too widespread and too significant to be ignored (Tytler, 2014).

In addressing the issue of scientific illiteracy, the 'Science for All' movement aims to ensure equality of educational opportunity through the provision of meaningful experiences in science for all students (Kembara et al., 2020). By 'Science for All,' I am referring to the movement aimed at making science more accessible, particularly to groups that have traditionally shunned science, hoping to increase scientific literacy amongst the general population (Mutegi, 2011). Interestingly, the introduction of the sciences into educational institutions of "all grades" has its roots in eighteenth century Germany while the United States began emphasizing science in schools during the first half of the nineteenth century in all secondary (high school) institutions (Graves, 1916).

This paper will focus primarily on scientific literacy as part of the North American 'Science for All' movement while demonstrating how scientific literacy relates to the larger field identified by the term 'curriculum studies.' I will begin with a historical examination of illiteracy in science as it relates to

Address of Corresponding Author

Emilio Landolfi, PhD, Faculty of Health Sciences, Kinesiology, Abbotsford campus, D3103, Canada.

emilio.landolfi@ufv.ca

0000-0002-9854-7383

How to cite: Landolfi, E. (2023). Scientific literacy as part of the science-for-all movement. *International Journal of Didactical Studies, 4*(1), 20382. https://doi.org/10.33902/ijods.202320382

traditional approaches to science education and how the 'Science for All' movement has attempted to respond to the need for increasing scientific literacy amongst the masses. Furthermore, I will explore how the 'Science for All' movement relates to the larger field of 'Curriculum Studies' by examining how both positions emphasize becoming more analytical, extending students' range of perceptions, and broadening students' perspective of the world around them.

2. The Notion of Scientific Literacy

Science education in Westernized nations has conventionally aimed at producing highly qualified scientists (Hetherington, et al., 2020). Consequently, school science has evolved into a minority pursuit for those few students who are most likely to study science at the post-secondary level and take up careers as specialized technologists or research scientists (Reinhold et al., 2018). Science has become a gatekeeper, an elitist subject that is often used to restrict access to many remunerative vocations in professional fields (Kelly et al., 2020). H.E. Roscoe, the first President of the Association for Public School Science Masters, believed that school science was to be a method by which those who possessed the highest levels of competence and intelligence were to be sifted out from the significant populace of mediocrity (Sharp, 2017).

Science as a means of understanding practical applications in everyday life had disappeared from the curriculum by the 1870s, as school science gradually adopted a mission of producing the 'pure' researcher (Singer et al., 2006). Not only did this change turn off many students from science, but it also acted to constrain the development of most pupils to their full potential. When children became 'turned off' or completely disinterested, science teachers brushed it off as the student's lack of ability. This problem persisted for over a century and continues to affect students up to generation Z (Mji & Makgato, 2006).

Masses of people are living in a technological society who are scientifically and technologically uninformed (Yaffe, 2022). The withdrawal from science by many students once it is no longer mandatory in school (note that some high schools require no more than two high school science classes – grades 9 and 10 – to graduate) not only creates an environment conducive to scientific illiteracy but may also render a public who become increasingly dependent on the views of scientists to explain everyday occurrences during their lives (Tanchyk, 2022). By scientific illiterate, I am referring not only to a lack of competence with scientific and technical matters but also a deficiency of knowledge and understanding required to read newspaper articles, follow TV programs, and engage in informed discussions about science (Grba, 2021). A fundamental knowledge of science is essential to understanding contemporary issues concerning one's health – particularly with respect to SARS, H1N1, Avian Flu virus, Covid, anti – vaccine movements, etc., as well as knowledge of human impact on the environment.

The American-based National Academies of Sciences, Engineering and Medicine ([NASEM], 2016) have argued that contemporary approaches to teaching science have been ineffective in satisfying students' requirements for a functional science consistent with the experiences of students in the real world. Seminal work by Young and Whitty (1976. p. 29) identified five ways in which conventional science education has failed to meet the real needs of students in the past;

a) School science separates science from pupils' everyday lives, and in particular, their non-school knowledge of the natural world.

b) School science, reflecting the individualism that is often seen as an inescapable part of scientific discovery, separates pupils from each other and any sense of link with others who have engaged in similar problems.

c) From its establishment, school science has sustained a separation of knowledge from its use. There has been a disregard for technology - especially in the more able curriculum.

d) School science separates pupils and teachers from themselves as people, by presenting it as the 'school subjects' - physics, chemistry, and biology - forgetful not only of their history but of the physics, chemistry, and biology of how people relate to environment.

e) In the process of schooling science, it has progressively been separated, in assumptions, organization and promotional hierarchies of the school, not only from technology and pupils' and teachers' everyday lives but from the range of other inquiries and activities within the school - history, art, politics, music and literature.

Schools should, at the very least, ensure that all students receive a basic level of literacy in science, as well as challenge those students who are more scientifically gifted. Students must gain literacy in science so they can make well-informed decisions and become responsible adults. By scientific literacy, I am not referring to a specific body or content of knowledge but to a general ability to follow the reasoning in science (PISA, 2013). The Programme for International Student Assessment [PISA] is a worldwide study by the

Organization for Economic Co-operation and Development [OECD] that clarifies what 15-year-old students should know and be able to do within appropriate personal, social, and global contexts. Their definition of scientific literacy is "the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen. A scientifically literate person is willing to engage in reasoned discourse about science and technology, which requires the competencies to explain phenomena scientifically – recognize, offer and evaluate explanations for a range of natural and technological phenomena; evaluate and design scientific inquiry – describe and appraise scientific investigations and propose ways of addressing questions scientifically, and interpret data and evidence scientifically – analyze and evaluate data, claims and arguments in a variety of representations and draw appropriate scientific conclusions" (OECD, 2017 p. 22).

Perhaps there is no clearer example of the need for greater scientific literacy than the COVID pandemic and subsequent overflow of information available to the public. Undoubtedly, a greater comprehension of science would be of tremendous value to students for being able to remain objective while applying a critical lens to understanding the coronavirus and how it impacts their lives (Crowell & Addy, 2018).

While there is no universally accepted and undisputedly correct definition of scientific literacy, the objective of school science should be to enhance students' educational development. Science education should not simply be about producing research scientists to remain competitive with other countries on a global scale if the goal is to enrich all students understanding of science. Moreover, scientific literacy must also reflect cultural awareness. Unfortunately, the traditional science curriculum leaves students foreign to their own culture (Boutte et al., 2010). Thus, the provision of appropriate experiences in school science could be seen as a means of helping students better relate to themselves, and others, while understanding who they truly are. An essential component of science education is stimulating interest in the subject, regardless of whether a student will become a research scientist (Brunsell & Fleming, 2014).

The sad reality, however, is that many students are left feeling alienated by their school science experiences (Blum, 2012). What is needed is an approach that would help students overcome their general feelings of hostility toward science. For many students, school science is perceived as extremely 'subject-oriented' and not 'learner-oriented.' Students view science as a method and often believe that they must subordinate a sense of themselves to this method. There is a longing to learn about useable science, practical applications, and how science could be contextualized in the real world (Germain, 2019).

Science, as both a subject in school and a means for understanding the interrelationships between science and society, is far too valuable to be limited to just a select few. Science is part of necessary preparation for modern life. Scientific ways of thinking can be applied in all practical affairs, and everybody needs to appreciate how understanding science can enhance their life (Brotman & Moore, 2008). Science is essential knowledge and must not be restricted to a distinct group of people. All citizens need a functional understanding of scientific concepts to make informed decisions regarding their health and the environment, pursue careers in technological fields, and think clearly. By keeping many students scientifically illiterate, a significant group of the population remain incapable of making educated, informed choices on science-related issues and how these issues impact their everyday lives (Pasek, 2018).

In trying to understand scientific knowledge, everyday citizens have often had to rely on the mediation and interpretation of an established group of eminent specialists. I believe that science knowledge, or knowledge of science and related issues, is a 'common good.' Scientific literacy is about empowerment. It is about letting students understand science's impact on their lives; it is about enabling students to make sensible decisions and become responsible human beings. Educators must ensure that science is accessible to all citizens. Students should come to understand what science is and then be allowed to make decisions on their own. Knowledge of science, as a way of thinking, a way of knowing, and a way of understanding the world around us, can help students better understand the values and conditions affecting their lives. The goal must be to help all students become scientifically literate (Snow & Dibner, 2016).

3. Curriculum Studies

While the term curriculum, as a course of study, came into prevalent use in North America in the late nineteenth and early twentieth centuries, numerous scholars have struggled with the meaning of 'curriculum studies' (Schubert, 2022). Consequently, the curriculum has come to mean many different things to different people. The term is so equivocal that there is considerable inconsistency even amongst leading experts. Maryanti et al. (2021) describe it as a slippery concept, a weasel word surrounded by much ambiguity. To some, curriculum represents volumes of uninterpretable materials that are unattractive, uninteresting, and overpowering. Conversely, others view the curriculum as the very soul of the school that embraces students' lives (Macalister, 2019).

The Ontario Institute for Studies in Education of the University of Toronto [OISE], an international leader in educational research and activity, defines curriculum studies as a forum for systematic reflection on the substance (subject matter, courses, programs), purposes, and practices used for bringing about learning in educational settings (OISE, 2021, p. 39). The Department of Curriculum, Teaching and Learning at OISE concerns itself with fundamental issues as what should be studied? Why? By whom? In what ways? And in what settings? "Reflection upon such issues involves an interplay among the major components of education: subject matter, learning, teaching, and the larger social, political, and economic contexts as well as the immediate instructional situation" (OISE, 2021, p. 39). Regardless of one's interpretation, perhaps the most visible feature of the curriculum is that it focuses on what is to be learned.

Progressive advancements in curriculum, however, do not occur outside the realm of normal, everyday activity. Changes in knowledge (including knowledge about learning), and political and economic developments have significantly influenced what is taught in schools (Murr, 2021). For example, science education from the 1950's to the 1970's was greatly affected by launching the first Russian Sputnik satellite. Many North Americans perceived this as a serious political threat, and school science embraced a mandate geared toward producing research scientists, which strongly influenced the type, content, and nature of science pupils received in schools (El Takach & Yacoubian, 2020). Notwithstanding, during times of crisis, schools have been more concerned with helping students understand the dilemmas and social issues impacting contemporary society (Hawick et al., 2017).

More recently, efforts directed at curriculum reform have been strongly driven by economic and commercial needs. Such was the case in the 1980s when fear of North America's inability to keep up with growing foreign markets, particularly the relatively cheap supply of labor in Asia, greatly influenced the curriculum in science. Indeed, some perceive school science education as essential to producing the scientific and technological professionals who will enable the USA to compete economically with global markets (Carnoy, 2014).

But the curriculum is about so much more than pursuing current doctrines or contemporary trends. While no single course of study can guarantee the desired outcome, the curriculum should not be exclusively about efficiency, competence, or cost-effectiveness. Curriculum needs to extend beyond present-day political or economic needs. It should be about more than just satisfying financial and industrial requirements defined by the few (Henderson et al., 2018). Curriculum needs to respond to the real crisis in society; the necessity to make science more accessible to all students to make more people aware of the role science plays in their everyday life. Science curriculum should be about education for responsible citizenry: helping people fight their feelings of powerlessness and helping students build their confidence in the real world. The curriculum must be connected to the lives of students. Education is a process that necessitates an embodiment of the finest elements of what makes people human and liberates them in teaching people what is of value.

4. Similarities between Curriculum Studies and Scientific Literacy

Tyler (1949), in his landmark book titled *Basic Principles of Curriculum and Instruction,* asks, "what educational purpose should schools seek to attain (p. 1)?" He perceives the curriculum as a set of educational objectives and schools as the agency for helping students meet these goals. Tyler appeals for responses to the question, "what can your subject contribute to the education of young people who are not going to be specialists in your field; what can your subject contribute to the layman, the garden variety of citizen" (Tyler, 1949, p. 26).

Concerning science education, Tyler (1949) suggests that science, for the 'garden variety of citizen,' could help provide a clearer understanding of the world as it is viewed by the scientist and man's relation to it and the place of the world in the larger universe. This type of awareness would assist in extending a student's range of perceptions, helping them view the world more clearly and critically. It could help students see beyond the obvious. Through developing interests and values in science, students will then be able to express themselves and communicate more effectively (Tyler, 1949). Thus, educational objectives in non-specialist subjects (i.e., English students enrolled in a mandatory science course) can contribute to the larger pedagogical goals of broadening students' vision and perspective of the world around them. "Science can be taught to encourage reflective thinking and to develop other characteristics of personality such as creative thinking, aesthetic appreciation, tolerance, social sensitivity, and self-direction" (Tyler, 1949, p. 32). Tyler views these characteristics, along with strong democratic values, as essential to helping students lead satisfying and fulfilling lives. He also firmly believes that these ideals are what all educational programs (i.e., the curriculum) of the school should aim for.

Long considered an innovator in the file of curriculum studies, Ralph Tyler's work challenged the philosophical assumption of whether there should be a further education for different classes of society - this assumption is the basis upon which the 'Science for All' movement was founded. One of the primary goals of the 'Science for All' movement is to ensure that all students obtain a fundamental capacity to understand and express their views on science-related issues (DeBoer, 2019). And suppose one believes in the value of a common democratic education for all, in that case every effort should be made to select common objectives that are personally and socially significant to a wide variety of young people. Tyler probed this query further by asking whether public school education should strive primarily toward the general education of the everyday citizen or at specific vocational preparation (Bhuttah, et al., 2019).

Note that public school education is about the North American system. If one holds to a more generalized theory of learning, then they (i.e., educators) would come to view learning objectives in more general terms and believe in the value of teaching all children to apply scientific principles in explaining everyday phenomena.

5. Conclusion

Throughout this paper, considerable attention has been directed towards demonstrating how traditional approaches to science education have failed to provide many North American students with a basic functional understanding of science as a method for understanding the world. Arguments have been made for the 'Science for All' movement in assuring scientific literacy and equality of educational opportunity to the broader population of students.

By examining the meaning and purpose of curriculum studies, this work has also highlighted similarities between the larger field of curriculum and the domain of scientific literacy. In doing so, I have demonstrated that the problem of illiteracy in science requires systematic and methodical consideration. Consequently, it is within the larger field identified by the term 'curriculum studies' that science education could truly begin to address the needs of a North American society which demands a functional level of scientific and technological knowledge for all (Campbell-Phillips, 2020). Only by reflecting on the methods used for teaching and learning, as well as content and subject matter, can the domain of curriculum studies begin to effectively focus on how curriculum could best be structured to meet the needs of society.

Funding: No funding source is reported for this study.

Declaration of interest: No conflict of interest is declared by author.

References

Bhuttah, T. M., Xiaoduan, C., Ullah, H., & Javed, S. (2019). Analysis of curriculum development stages from the perspective of Tyler, Taba and Wheeler. *European Journal of Social Sciences, 58*(1), 14-22.

Blum, D. (2012, June 2020). *How to stop science alienation syndrome*. Slate. https://slate.com/technology/2012/06/science-education-should-be-split-into-two-tracks.html

Boutte G., Kelly-Jackson C., & Johnson, G. L. (2010). Culturally relevant teaching in science classrooms: Addressing academic achievement, cultural competence, and critical consciousness. *International Journal of Multicultural Education, 12*(2), 1 – 20.

Brotman, J.S., & Mensah, F.M. (2008). Girls and science: A review of four themes in the science education literature. *Journal of Research in Science Teaching, 45*(9), 971–1002. https://doi.org/10.1002/tea.20241

Brunsell, E., Fleming, M. A., Opitz, M. F., & Ford, M. P. (2014). *Engaging minds in science and math classrooms: The surprising power of joy*. ASCD Publications.

Campbell-Phillips, S. (2020). Education and curriculum reform: The impact they have on Learning. *Budapest International Research and Critics in Linguistics and Education Journal*, *3*(2), 1074-1082. https://doi.org/10.33258/birle.v3i2.1036

Carnoy, M. (2014). Globalization and educational reform. In N. P. Stromquist & K. Monkman (Eds.), *Globalization and education: Integration and contestation across cultures* (pp. 21-38). R&L Education.

Crowell, M., & Addy, J. (2018). *The ingredients of scientific illiteracy* [Conference presentation]. 22nd Annual Georgia College Student Research Conference, Milledgeville, Georgia. https://kb.gcsu.edu/cgi/viewcontent.cgi?article=1704&context=src

DeBoer, G. E. (2019). *A history of ideas in science education*. NY: Teachers College Press.

El Takach, S., & Yacoubian, H. A. (2020). Science teachers' and their students' perceptions of science and scientists. *International Journal of Education in Mathematics, Science and Technology*, *8*(1), 65-75. https://doi.org/10.46328/ijemst.v8i1.806

Germain, A. (2019, October 25). *The aims of science education and the science curriculum*. Medium. https://medium.com/dr-alice-g-on-education/the-aims-of-science-education and-the-science-curriculum-acc43e33ad62

Glick, M., Wolff, M. S., & Carrasco-Labra, A. (2021). COVID-19 and scientific illiteracy, a syndemic. *Journal of the American Dental Association*, *151*(12), 967- 968. https://doi.org/10.1016/j.adaj.2021.09.013

Graves, F. (1916). *A student's history of education*. The Macmillan Company.

Grba, M. (2021). What cost is scientific illiteracy in time of global pandemic? *Medias Research, 10*(19), 2987-3008. https://10.46640/imr.10.19.3

Hawick, L., Cleland, J., & Kitto, S. (2017). Getting off the carousel: Exploring the wicked problem of curriculum reform. *Perspectives on Medical Education,* 6(1), 337–343. https://doi.org/10.1007/s40037-017-0371-z

Henderson, J. G., Castner, D. J., & Schneider, J. L. (2018). *Democratic curriculum leadership: Critical awareness to pragmatic artistry*. Rowman & Littlefield Publishers.

Hetherington, L., Chappell, K., Keene, H. R., Wren, H., Cukurova, M., Hathaway, C., Sotiriou, S. A., & Bogner, F. (2020). International educators' perspectives on the purpose of science education and the relationship between school science and creativity, *Research in Science & Technological Education*, *38(*1), 19-41. https://doi.org/10.1080/02635143.2019.1575803

Kazempour, M. (2014). I can't teach science! A case study of an elementary pre-service teacher's intersection of science experiences, beliefs, attitude, and self-efficacy. *International Journal of Environmental & Science Education International, 9*(1), 77-96. https://10.12973/ijese.2014.204a

Kelly, R., Garr, O. M., Leahy, K., & Goos, M. (2020). An investigation of university students and professionals' professional STEM identity status. *Journal of Science Education and Technology, 29*(4), 536–546. https://doi.org/10.1007/s10956-020-09834-8

Kembara, M. D., Hanny, R., Gantina, N., Kusumawati, I., Budimansyah, D., Sunarsi, D., & Khoiri, A. (2020). Scientific literacy profile of student teachers on science for all context. *Solid State Technology*, *63*(6), 1-13.

Macalister, J. (2019). *Language curriculum design*. Routledge.

Maryanti, R., Nandiyanto, A. B. D., Hufad, A., & Sunardi, S. (2021). Science education for students with special needs in Indonesia: From definition, systematic review, education system, to curriculum. *Indonesian Journal of Community and Special Needs Education,* *1*(1), 1-8. https://doi.org/10.17509/ijcsne.v1i1.32653

Mji, A., & Makgato, M. (2006). Factors associated with high school learners' poor performance: A spotlight on mathematics and physical science. *South African Journal of Education, 26*(2), 253–266.

Murr, S. (2021). What gets to be taught: The canon, truth-telling and text selection. *Idiom*, *57*(2), 14-17.

Mutegi, J. W. (2011), The inadequacies of "science for all" and the necessity and nature of a socially transformative curriculum approach for African American science education. *Journal of Research in Science Teaching, 248*(3), 301-316. https://doi.org/10.1002/tea.20410

National Academies of Sciences, Engineering and Medicine. (2016) *Science literacy: Concepts, contexts, and consequences*. https://www.nap.edu/read/23595/chapter/7

Ontario Institute for Studies in Education. (2021). *OISE Graduate studies in education bulletin 2021-2022*. University of Toronto.

Organisation for Economic Co-operation and Development. (2017). *PISA 2015 Assessment and Analytical Framework: Science, Reading, Mathematic, Financial Literacy and Collaborative Problem Solving*. PISA, OECD Publishing. https://doi.org/10.1787/9789264281820-en

Pasek, J. (2018). It's not my consensus: Motivated reasoning and the sources of scientific illiteracy. *Public Understanding of Science*, *27*(7), 787–806. https://doi.org/10.1177/0963662517733681

PISA (2013) *2015 Science Framework*. (Report). OECD. Available at: https://www.oecd.org/publications/pisa-2015-assessment-and-analytical-framework-9789264281820-en.htm

Reinhold, S., Holzberger, D., & Seidel, T. (2018). Encouraging a career in science: a research review of secondary schools' effects on students' STEM orientation. *Studies in Science Education*, *54*(1), 69-103. https://doi.org/10.1080/03057267.2018.1442900

Schubert, W. H. (2022). Curriculum studies: Definitions and dimensions. In W. H. Schubert & M. F. He (Eds.), *Oxford encyclopedia of curriculum studies* (pp. 229-237). Oxford University Press.

Sharp, R. (2017). *Knowledge, ideology and the politics of schooling: Towards a Marxist analysis of education*. Routledge.

Singer S. R., Hilton M. L., & Schweingruber, H. A. (Eds.). (2006). *America's lab report: Investigations in high school science*. National Academies Press. https://nap.nationalacademies.org/read/11311/chapter/1

Snow, C. E., & Dibner, K. A. (Eds.). (2016). *Science literacy: Concepts, contexts, and consequences*. National Academies Press.

Tanchyk, A. (2022). Scientific illiteracy. *Journal of the American Dental Association, 153*(5), 404. https://doi.org/10.1016/j.adaj.2021.12.015

Tyler, R. W. (1949). *Basic principles of curriculum and instruction*. University of Chicago Press.

Tytler, R. (2014) Attitudes, identity, and aspirations toward science. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education, volume II* (pp. 82-103). Routledge.

Yaffe, P, (2022). Workings of science: Can mankind survive scientific illiteracy? *Ubiquity*, *1*(1), 1–12. https://doi.org/10.1145/3512332

Young, M. & Whitty, G. (Eds.). (1976). *Explorations in the politics of school knowledge*. Studies in Education Ltd.