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# Scientific Literacy Versus Scientific Competency: Understanding the Conceptual Division

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**ABSTRACT**
Science and technology have transformed human life by addressing numerous critical issues and challenges worldwide. Simultaneously, the misuse and overuse of it have pushed many creatures towards extinction, creating a threat to human existence as well. Thus, the 21st century urgently demands scientifically literate citizens who can make informed and responsible decisions. Still, scientific literacy alone is not sufficient to resolve this complex challenge in the world. Hence, the need for more competent scientific and skilled persons is crucial for sustainable innovation and solutions for a better world to live in. This paper has explored the distinctions between the two terms, scientific literacy and scientific competency; these are often used interchangeably. While scientific literacy refers to basic abilities of understanding science and phenomena through reading, writing, and debating, scientific competency goes a step ahead with the ability to apply science to solve real-world critical problems and contribute to scientific advancements. The paper emphasizes the importance of fostering both the concepts for an advanced and inclusive world through effective pedagogical strategies where project-based learning, reflective thinking, inquiry-based learning, etc, are emphasized. The insights into the division between scientific literacy and competency can empower educators, teachers, curriculum framers, and policy makers to create the educational framework in such a way that can create scientifically literate and competent persons for an ecologically and technologically balanced world.

**Keywords:** Scientific literacy, Scientific competency, scientific knowledge, informed citizens, and Decision making.

## Introduction

Science and technology have restructured the world and beyond in this 21$^{st}$ century with various advancements. It acts as a tool for humans to stand against the challenges of life and nature. Maintaining health and fitness to prediction of natural calamities and sustaining the lives from it, science has marked it's importance in human lives (Ma, Gryshova, Khaustova, Reshetnyak, Shcherbata, Bobrovnyk, & Khaustov, 2022; Tawfik,2024; Betz, Arora, Assal, Azevedo, Baldwin, Becker, Bostock, Cheng, Egle, Ferrari, Schneider-Futschik, Gerhardy, Hammes, Harzheim, Herget, Jauset, Kretschmer, Lammie, Kloss, Marquis Fernandes, Mitrofan, Myrgorodska, Nedbalek, Neumann, Paffenholz, Pascual Ponce, Rogell, Savic, Velikova, Schumacher, Weisshaar, Yahya, Yang, & Zhao, 2023). Despite having countless benefits, the negative side of science and technology can't be overlooked. Recent conflicts like the Russia-Ukraine war, India-Pakistan conflict, the USA's attack on Iran's nuclear facilities, Heavy floods in Argentina, Deadly landslide in Papua, Powerful earthquake in Taiwan, global warming, and rapid melting of glaciers reflect how the development and misuse of science and technology can cause global crises directly or indirectly. Thus, causing damage to humans and other lives (Odimegwu,2025; Tomlinson, Torrance, & Ripple, 2024; Desalegn, Abdela, 2025; Zwijnenburg & Ballinger, 2023). This designates the development of science and technology as a threat to the world. The threat comes from the misuse or overuse of science by humans only. This reveals the deficiency of proper knowledge and accountable use of science (Pandian, Mustaffa, Mahalingam, Paramasivam, Prince, Gajendiren, Mohammad, & Varanasi, 2024; He, Feng, Min, Yi, Tang, Li, Zhang, Chen, Zhou, Xie, Zhang, Yu, & Zheng, 2023; Anderljung, & Hazell, 2023). In order to make the world an inclusive place to live in, the role of science can't be ignored. Hence, the need of the hour is to have scientific literate persons in the 21st century who can make informed and effective use of science.

The 21st century demands scientific literate citizens or scientific competent citizens for a sustainable world to live in? Are both concepts same? Though both the terms scientific competency and literacy are interchangeable, they are essentially different. There is a critical difference between both the terms (Bybee, 1997; Holbrook, & Rannikmae, 2009; National Research Council, 2012). Scientific literacy is about the ability to understand the scientific knowledge, phenomena and the underlying principles whereas scientific competency refers to the ability to apply the scientific knowledge, ideas and skills in practical contexts to solve various complex problems of the society and nature through intense scientific inquiry and being active participant in scientific endeavours(Singh, & Singh, 2016; Bybee, 1997; Holbrook, & Rannikmae, 2009; National Research Council, 2012).

As the growing demand for science education and informed citizens for a scientifically advanced society is essential, this paper explores the critical difference between scientific literacy and scientific competency while highlighting the importance of fostering both qualities among individuals of all age groups for a holistic 21st-century society.

**Scientific literacy**

Literacy refers to the process of knowing. It is the specific way of thinking about and performing reading and writing for expressing ideas or thoughts in writing within a particular context (Keefe & Copeland, 2011; Falloon, 2020). Hence, scientific literacy is the ability to understand scientific ideas and the underlying principles and apply them in daily life. It deals with the awareness of how science and technology shape the material, intellectual, and cultural environment around us (Kumar & Choudhary, 2024; Singh & Singh, 2016). The knowledge and skills of a scientifically literate person allow one to understand science and apply it in daily life situations. Scientific literacy enables an individual to get engaged with scientific concepts and phenomena at a foundational level (Ploj Virtič, 2022; Osborne & Allchin, 2024). A scientifically literate person is conversationally competent, where he/she is able to have conversational familiarity with important science concepts. It enables an individual to explore the new scientific information and distinguish between reliable, legitimate scientific resources and false and misleading information sources that can create misconceptions (Ploj Virtič, 2022; Osborne & Allchin, 2024). The competencies of scientific literacy are: explaining scientific phenomena, designing and evaluating scientific investigations, interpreting scientific data and facts (Widayoko, Femilia, Lesmono, Sudjatmi, Prastiwi, Munfarikha, 2019). Scientific Literacy means competencies of the students to use scientific knowledge and thinking, consisting of three competencies: identification of scientific issues, explanation of scientific phenomena, and usage of scientific evidence (Udompong, Traiwichitkhun, and Wongwanich,2014).

The importance of science literacy is growing rapidly as the development of science occurs. The concern of scientific literacy was more in 2020 during the pandemic (COVID-19). People became biased through various online social media information to protect themselves from the deadly disease (Gu & Feng, 2022). It hurt the process of fighting against the pandemic and its deadly impacts. The blind beliefs and misconceptions make people fail in distinguishing between rumours and objective scientific facts. In order to cope with the present advanced world, it is essential to have scientific literacy for everyone, from children to adults.

**Science competency**

Competencies are a set of knowledge, creating the ability of an individual to get involved in the knowledge, of knowing how(it's about the skills, habits, and capacities) and knowing how to be(it's about the values and attitudes(Veliz, Diaz, and Rodriguez,2015). Hence, the science competency is the ability to construct knowledge in the field of both science and technology that solves various issues related to different contexts(Torres, Blanchar, and Freile,2015). According to OECD (2010 Scientific competencies include the following: scientific thinking. Such as:

1. Inductive or deductive reasoning
2. Critical and integrated thinking
3. Transforming representations
4. Constructing and communicating arguments and explanations based on data
5. Using models for thinking and
6. Using mathematical processes, knowledge, and skill

Competency is a broader term than literacy that refers to the ability to perform any task effectively and successfully. It is the application of learned knowledge effectively and beneficially (Albino, 2018; Anunobi & Udem, 2014). Though scientific literacy and competency are related to each other, there is a critical difference between the two terms. It is highlighted in table-1.

**Table-1**

| Scientific literacy | Scientific competency |
|---|---|
| It includes the basic skills of understanding science. | It includes the advanced skills of applying scientific knowledge proficiently. |
| It includes the ability to read, write, and understand the science and underlying principles of scientific phenomena. | It includes the ability to think critically about the scientific and technological phenomena while getting involved in research and advancement. |
| Principally, scientific literacy is all about knowing science theoretically and applying it in life at a very basic level. | Scientific competency is all about doing.<br>That is applying scientific knowledge for the advancement of the disciplines and society as well by solving complex problems. |
| Scientific literacy creates the foundation of scientific competency. | Scientific competency stands upon scientific literacy. |
| It can be acquired through formal, informal as well and nonformal education. | This needs proper training, professional scaffolding, proper practice, and research. |

| | |
|---|---|
| It creates informed citizens, thus making them good at decision-making, who can distinguish between authentic scientific information and unreliable information and misinformation. | This creates efficient scientists and researchers who can solve complex problems effectively through innovative scientific methods. |
| Scientific literacy basically includes understanding of scientific theories, principles and phenomena from a theoretical aspect. | Scientific competency mostly includes advanced theoretical and practical application of scientific concepts and phenomena. |

**(Table 1: Difference between scientific literacy and scientific competency)**

**Pedagogical strategies to cultivate scientific literacy and competency**

The importance of being a scientifically literate person is equally important as being a scientifically competent one. These are not the qualities to merely learn, yet these need to be inculcated in the thought process and approach of each individual. A formal classroom setting provides a wider scope in implementing these skills and attitudes in the minds and will of young minds. Thus, certain pedagogical approaches to cultivate both scientific literacy and competency can be as follows:

- Employing inquiry-based learning methods where each learner gets the opportunity to explore the scientific phenomena and related principles through guided instructions (Vindi Marta & Asrizal, 2022; Syahgiah, Zan, & Asrizal, 2022).
- Project-based teaching and learning methods allow learners to explore their immediate real-world problems and find solutions, allowing for the development of critical thinking and problem-solving. Thus, allowing to bridge the gap between the theoretical knowledge of science and it's practical relevancy (Markula & Aksela, 2022; Oyewo, Ramaila, & Mavuru, 2022; Santos, Carolina; Rybska, Eliza; Klichowski, Michal; Jankowiak, Barbara; Jaskulska, Sylwia; Domingues, Nuno; Carvalho, Diana; Rocha, Tânia; Paredes, Hugo; Martins, Paulo; & Rocha, João, 2023; McKinney, 2023; Pozuelo-Muñoz, Jorge; Calvo-Zueco, Elena; Sánchez-Sánchez, Ester; Cascarosa-Salillas, Esther, 2023).
- Making the nature of science an integral part of the curriculum and textbooks, which can create learners' awareness about science and its nature effectively (Fricke & Reinisch, 2023; Ramnarain, 2024; Pimenta, Okan, & Molnár, 2025).
- Connecting classrooms to society and community allows young minds to explore the controversial social and environmental challenges. Thus, making them explore the solutions in a scientific way (Vance-Chalcraft, Smith, Allen, Bowser, Cooper, Jelks, Karl, Kodner, & Laslo, 2024; Jeong, Steele, & Upadhyay, 2023; Adams, Granados, Beatty, & Ballen, 2024).
- Creating media literacy creates awareness and the ability to distinguish between fake information resources and authentic scientific information (Siani, Joseph, & Dacin, 2024; Allaire-Duquette, Hasni, Drouin, Groleau, Mahhou, Legault, Khayat, Carignan, & Ayotte-Beaudet, 2025; Alon, Rahimi, & Tahar, 2024).
- Conducting scientific debates, discussions, and science exhibitions where the individual talents get a platform to be encouraged and get appropriate guidance. It enhances the critical thinking, research, analysis, and communication skills (Obaid, 2022; Mumtaz & Latif, 2017; Meschi, Shirahmadi, Amiri, & Ebrahimi-Siaghi, 2024; Park, Kim, & Jeong, 2019; Casado-Ledesma, Cuevas, & Martín, 2023).
- Proper use of technology-integrated pedagogical strategies that help in minimising the abstract concepts of science, thus creating more interest among learners (Kewalramani, Arnott, & Dardanou, 2020; Lagura, 2022; Ojetunde & Ramnarain, 2023; DeCoito, 2020; Maričić & Lavicza, 2024).

- Interdisciplinary pedagogical strategies can help remove the disciplinary barriers existing in students' minds and explore the omnipresence of science and it's application in a practical manner (Tytler, Mulligan, Prain, White, Xu, Kirk, Nielsen, & Speldewinde, 2021; Kennedy & Odell, 2024).
- Establishing proper science labs and providing sufficient equipment that provides each learner access to explore science at their own pace. Even the virtual labs can serve the purpose to a maximum extent (Zhao, 2025; Tufino, Onorato, & Oss, 2024; Sapriati, Suhandoko, Yundayani, Karim, Kusmawan, Mohd Adnan, & Suhandoko, 2023).

**Conclusion**

The 21st century is the era of science and technology. Yet, the fundamental distinction between scientific literacy and competency is not clear to many people. It is still used interchangeably. For effective and informed education and practice, it is necessary to understand clearly the relation and distinction between the terms. Both terms have different purposes and different outcomes. The critical understanding of the dissimilarities can help teachers, educators, policy makers, and curriculum makers to plot the education accordingly that nurtures both the theoretical and practical aspects of science and technology for the betterment of society and the environment. Scientific literacy provides foundational knowledge, whereas scientific competency provides practical application of the learned ideas. For an ecological and technological balanced future, pedagogical strategies that include fostering critical thinking, interdisciplinary learning, reflective thinking, and inquiry-based learning must be practiced and fostered effectively.

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