



# Reading Literacy, Scientific Literacy and Mathematical Literacy's Influence on Students' Academic Achievements

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**Abstract:** Literacy has been widely discussing nowadays and it has become a core competence of today's students. Primary students' literacy can be classified into three types, which are, reading literacy, scientific literacy and mathematical literacy. This article presents the definitions of each literacy, discusses the relationship between each literacy and its impact on students' academic achievements and gives different strategies to develop primary students' literacies. Moreover, suggestions are also put forward for the teachers and schools to better cultivate students' literacies.

**Keywords:** reading literacy, scientific literacy, mathematical literacy, academic achievements

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## 1. Introduction

During my time as an examiner for the Chinese Social Arts Proficiency Test, I found a strange phenomenon that some elementary school students do not like reading books, and they even hate going to school. It is my experience of working with an examiner that has driven this research. It is hoped that this research will contribute to a deeper understanding of English reading literacy, scientific literacy and mathematical literacy. The specific objective of this study was to explore the definition and impact of reading literacy, science literacy, and mathematical literacy and to propose ways to develop students' scientific literacy, reading literacy, and mathematical literacy. If we can understand what influence reading literacy, scientific literacy, and mathematical literacy have on students, then it will be able to help teachers to develop a lesson plan that students would enjoy. This paper is divided into four parts. The first part deals with the definition and types of literacy. The second section describes the impact of reading literacy and discusses how to develop reading literacy from multiple perspectives, including teacher's level, school level, and policy level. The third part of the paper explains the impact of scientific literacy and how to build students' scientific literacy and compares definitions of scientific literacy from a global perspective (e.g., United States, Canada, Australia). The fourth part then describes the impact of mathematical literacy and suggests that critical thinking and children's storybooks are essential for developing mathematical literacy.

## 2. Types and definitions of literacy

According to Nurul et al. (2020), literacy is a driver of sustainable development because it can contribute to the labor market, increase employment opportunities, and help students adapt quickly to social development. Thus, from a career development perspective, literacy has a profound impact on students. Traditionally, literacy has been defined as the ability to read and write (Nurul et al., 2020). Nowadays, literacy is defined as the process of constructing, integrating, and thinking about meaningful content in a social context through engagement with a variety of vocabulary and the appropriate use of reading, writing, and speaking activities (Frankel et al., 2016). With the in-depth study of literacy, literacy has been divided into three types, which are reading literacy, scientific literacy, and mathematical literacy (Kastberg et al., 2016; Xin Ma, 2008). The following is a brief description of reading literacy, scientific literacy and mathematical literacy.

Nurul et al. (2020) noted that reading literacy is the ability to understand, use, reflect on, and engage with written texts to achieve one's life goals better, develop one's potential, and participate in society as a whole. In other words, good reading literacy is crucial to students' future careers because it enhances their cognitive abilities (Nurul et al., 2020). In addition, mathematical literacy is defined as one's ability to express, use, and interpret mathematics in a variety of contexts, and it includes mathematical reasoning and the use of mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena (Nurul et al., 2020). For example, the geometric theory is often used to explain strange phenomena that occur in nature. Another advantage of mathematical literacy is that it helps people recognize the role of mathematics in the world, and it also helps them make the informed judgments and decisions necessary when facing complex problems (Nurul et al., 2020).

With regard to scientific literacy, it plays an essential catalytic role in science education in the 21st century. Nowadays,

there are various definitions of scientific literacy. For example, the Program for International Student Assessment (PISA) defines scientific literacy as the ability to apply learned scientific theories to real-life situations (OECD, 2017). In his analysis of scientific literacy, Hurd (1998) claims that scientific literacy is the ability to think rationally about the scientific problems one may encounter in one's lifetime. In my opinion, scientific literacy can use scientific knowledge to identify the issues and draw evidence-based conclusions to help people make decisions about societal issues. To conclude this section, the literature identifies three areas of literacy, which are reading literacy, scientific literacy, and mathematical literacy. The following part of this paper moves on to describe in more detail of the impact of reading literacy and scientific literacy, as well as mathematical literacy and how to build these literacies.

### **3. The impact of reading literacy on academic and economic fields**

Reading literacy has a profound impact on the development of regional economies. According to Nurul et al. (2020), one advantage of reading literacy is that it facilitates the development of educated, creative human resources designed to be flexible and responsive to changing times. A typical example of reading literacy is that students in Hong Kong possess a high level of reading skills in both Chinese and English from the elementary school level (Shek-Kam et al., 2013). In my opinion, these students with good English reading skills have a significant advantage in the highly competitive workplace in the future. One reason is that good English reading skills can create more business value for companies in Hong Kong. As noted by Tung (1997), our policy is to promote biliteracy (Chinese and English) and trilingualism (Cantonese and Mandarin, the spoken languages used throughout China) because it will facilitate effective communication and business exchange between Hong Kong and other countries and regions.

On the other hand, reading literacy plays a positive role in student's academic abilities, especially for graduate students. According to Delgadova (2015), reading literacy is the ability to read words, phrases, or the whole text quickly and is the ability to understand the content correctly. More specifically, reading literacy is finding the clear and implied meaning in a text, analyzing the content of the text and the information obtained, while being able to interpret the content and convey it correctly (Delgadova, 2015). In addition, reading literacy is also the ability to make judgments about a text and innovate on its content to gain new knowledge (Delgadova, 2015). For example, when graduate students write a dissertation, they need good reading literacy to go for creative content to avoid plagiarism. This view is supported by Delgadova (2015), who claims that reading is one of the critical skills in the academic environment since a great deal of knowledge is acquired through books, magazines and journals. Reading literacy is also a core competency in transforming information into comprehension (Delgadova, 2015).

In my view, one's reading literacy also affects one's academic performance. Ardhian et al. (2020) supported this view, who writes that students' success depends heavily on their reading skills. For example, in the end-of-semester exams, when students do not have enough knowledge to answer the test questions, this phenomenon will lead to low academic achievement. One reason is that most of the knowledge is acquired by students through reading activities (Somadayo et al., 2013). This section reviews the three critical aspects of the influence of reading literacy.

What's teacher's guidance to the development of students' reading literacy? Moving on now to consider how to build reading literacy. Firstly, schools should reinforce the formal reading and writing practices that students engage in at school, including some complex reading behaviors (e.g., critical thinking about the text content) (Curry et al., 2016). Secondly, teachers should expand students' home literacy practices, for example, by providing a variety of reading materials and creating a comfortable home reading environment (Curry et al., 2016). This view is supported by Pang et al. (2003), who argue that reading practice lists help improve students' reading literacy, including asking them to read long books with chapters and practical manuals. Thirdly, teachers should encourage students to read for enjoyment, not just to acquire skills. More specifically, teachers should allow students to choose their reading content and encourage impromptu interaction during the reading process, motivating them to read (Curry et al., 2016). As noted by Aljanahi and Alsheikh (2020), a correct approach to literacy is to immerse oneself in meaningful reading and writing and to focus on the process of reading and writing rather than adhering to conventional forms. Finally, teachers should facilitate conversations about tasks and stories or use books that students can easily understand for discussions, rather than just asking students to answer questions (Curry et al., 2016).

Moreover, to improve their reading skills more quickly, teachers should also set clear and individualized learning goals for each student. One important reason is that each student's reading ability is different (Alston-Abel & Berninger, 2018). For example, when students study independently at home, some students with weak reading skills are more likely to encounter literacy learning problems. According to Linda and Allan (1999), with the improvement of children's reading skills, they may spend more time on reading practice, whether for school-related assignments or just for plain fun. At the same time, spending

time on reading may improve children's positive attitudes toward reading, which may also lead to improved self-regulation and ultimately improved reading literacy (Linda & Allan, 1999). Therefore, teachers should provide enough time for students to read. So far, this paper mainly focuses on the impact of reading literacy and how to develop reading literacy. The following sections will discuss the impact of scientific literacy and how to build scientific literacy.

#### **4. The impact of scientific literacy on students**

In term of scientific literacy, it has a long history and wide application in science education. As noted by Goodrum et al. (2001), scientific literacy is a top priority for all citizens because it assists people to understand the world around them. For example, students can realize well-known physical theories (e.g., the theory of gravity) through their physics courses. Secondly, scientific literacy can also help students better engage in scientific discussions and ask questions. For instance, as the epidemic sweeping the world nowadays, students can take an evidence-based approach to discuss whether vaccines can effectively prevent the spread of the virus or not (Goodrum et al., 2001). Thirdly, scientific literacy also enables informed decisions about environmental, health and welfare issues (Goodrum et al., 2001). For example, as epidemics spread rapidly worldwide, many international students choose to study online; if they decide to learn face-to-face, they may be at risk of being infected with the virus. This view is supported by Harlen (2006), who argues that mastering scientific literacy means understanding the impact of science and technology in daily life and assessing the dangers and benefits of technological advances (e.g., the pros and cons of vaccines). Having scientific literacy can also use views, theory and scientific processes in decision making and be open to different perspectives based on scientific evidence.

On the other hand, according to the Vieira and Tenreiro-Vieira (2016) research, Canada has established four foundational announcements that describe crucial aspects of students' scientific literacy: (A) science, technology, community, and the surrounding; (B) skills needed for scientific and technical inquiry, problem-solving, communicating scientific ideas and consequences, collaborating, and making informed decisions; (C) knowledge, understanding, and application to interpret, integrate, and extend their knowledge; and (D) support for responsible acquisition and application of scientific and technical insight to achieve mutual benefit for themselves, society, and the environment. By comparing the definitions of scientific literacy above, it is easy to conclude that researchers share similarities that scientific literacy is the use of scientific theoretical knowledge to solve existing problems in society. In my opinion, scientific literacy can also reduce the existing difficulties in social development.

According to Yore et al. (2007), critical thinking is one of the ingredients of scientific literacy, and critical thinking is defined as deciding what to trust or do when facing challenge. In other words, when faced with a complex question, a scientifically literate person will decide what to believe or to do based on objective evidence and justify his or her claims and judgments. Therefore, critical thinking is essential in building scientific understanding and applying that understanding to decision making in science and technology issues. Norris and Ennis (1989) also argue that critical thinking involves problem-solving and decision making because it occurs in interactive context and requires rational decisions about what to do or believe.

In conclusion, scientific programs and practices improve to make judgments when solving problems in interactive circumstances. This section describes the impact of scientific literacy, and the next section discusses how to develop scientific literacy.

What's the influence of educational policies and critical thinking on scientific literacy? Let us now consider how to develop scientific literacy. Firstly, I believe that the support of educational policies will benefit students' scientific literacy. For example, in the United States, the foundation of scientific literacy for all Americans, the National Science Education Standards and the K-12 Science Education Framework are emphasized in the Curriculum Recommendations for Teaching Science from a Literacy Perspective (Science, 1990, 1994; Vieira & Tenreiro-Vieira, 2016). The framework file describes the fundamental science and engineering practices, cross-cutting concepts and disciplinary core principles that all students should master by the end of 12th grade to participate in open discussions of science-related challenges (Science, 1990, 1994; Vieira & Tenreiro-Vieira, 2016). There is no doubt that policy support plays a crucial role in developing students' scientific literacy.

On the other hand, Vieira and Tenreiro-Vieira (2016) argue that scientific literacy and critical thinking are essential components of science education, which is designed to prepare students to think and to be responsible citizens in a world increasingly influenced by science and technology. Therefore, In the science classroom, teachers should provide students with learning experiences in scientific literacy and critical thinking, for example, to allow students to participate in science experiments and encourage group discussions (Vieira & Tenreiro-Vieira, 2016). One reason is that it may trigger students to gain knowledge, form values, and to develop thinking skills in an integrated way to know how to act responsibly in their

personal and social contexts (Vieira & Tenreiro-Vieira, 2016). This section discusses the impact of scientific literacy and how to develop it. In the next section, the strengths of mathematical literacy will be discussed and the strategies of how to develop it.

## 5. The importance of mathematical literacy

The topic of mathematical literacy was first put forward in the United States in the 1980s (Yilmazer & Masal, 2014). The National Research Council (NRC) defined mathematics as the key to opportunity, and in the late 1990s, mathematical literacy was first articulated as such a broad goal of mathematics education (Pugalee, 1999). In terms of school mathematics standards, NCTM defines mathematical literacy as the scientific use of mathematical knowledge that should be made in various situations and contexts (Pugalee, 1999). For example, in some elementary schools in the Netherlands, schools assign students to classes based on their math test results (Stock et al., 2009). In my opinion, mathematical literacy is closely related to the access of elementary school students to higher education.

What's the impact of math curriculum and storybooks on mathematical literacy? In my opinion, the study of mathematics courses is crucial to the development of mathematical literacy. According to Kaiser and Willander (2005), to achieve mathematical literacy, a person should establish mathematical skills and have an inclusive cognitive attitude toward mathematics as well as confidence in mathematical performance (the so-called mathematical thinking structure), for example, elementary school teachers can assign arithmetic homework to students and also organize some math competitions for students. This view is supported by Yilmazer and Masal (2014), who states that as students advance from third to fifth grade, if they can develop an easy way to solve problems after learning arithmetic operations, it will contribute significantly to their math achievement. Secondly, Schools and families should encourage children to read storybooks. Whiteford (2020) claims that mathematical content and skills (e.g., sets, patterns, ordinal numbers, geometry, and geometric reasoning) have been found in various children's books, and students' mathematical skills can be enhanced through storybook reading. Thirdly, the support of relevant policies is essential for developing mathematical literacy. For example, the Australian government has enacted initiatives such as "Let's Read" and "Let's Count" to ensure the continued development of early numeracy and literacy skills (Whiteford, 2020). Finally, teachers should use critical thinking in science literacy to develop students' mathematical literacy. According to the study, students need to reflect on and gain insight into the problem to improve their mathematical literacy as they use data to argue for mathematical problems (Whiteford, 2020; Yilmazer & Masal, 2014). Therefore, teachers should encourage students to think critically about mathematical issues to develop their mathematical literacy.

## 6. Conclusion

This study set out to explain the definition of reading literacy, scientific literacy, and mathematical literacy. The second aim of this study is to investigate the effects of reading literacy, science literacy, and mathematical literacy and how to develop these literacies. This study identified that literacy has a positive impact on students' cognitive thinking skills, study motivation, and career development. In addition, literacy drives economic growth in a country and region (e.g., in the Hong Kong region). This study lays the groundwork for future research into how teachers scientifically develop lesson plans. The present study has gone some way towards enhancing our understanding of reading literacy, scientific literacy and mathematical literacy. This study also suggests that teachers can use storybooks and encourage students to critically improve reading literacy, mathematical literacy, and science literacy; at the school level, schools should offer students enough opportunities to participate in this literacy program; and at the national level, governments should promote policies and documents that support literacy development. For example, the Australia government's Let's Read program supports all students to engage in reading, and the American Council on Education's 2061 plan encourages schools to develop student literacy. A limitation of this study is that students with disabilities are not adequately considered (e.g., hard of hearing and visually impaired students). Despite its limitations, the study certainly adds to our understanding of literacy. Further research might explore how to improve reading literacy, scientific literacy, and mathematical literacy for students with disabilities.

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