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Science for citizenship: advances to face the challenges of training scientifically literate citizens in Chile

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ABSTRACT

In 2020, the subject Science for Citizenship was included in the Chilean school curriculum in response to the global challenges to move towards scientific literacy to encourage citizens to participate in decision making for their personal lives or in their participation socially. The objective of the research was to understand the contributions of the subject Science for Citizenship to the Chilean school curriculum to advance toward scientific literacy.

This article presents a descriptive analysis of the Chilean educational policy documents, based on the review of the purposes, approaches, modules, and learning

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objectives of the Science for Citizenship subject. The findings show that the curriculum promotes the acquisition, use, critical analysis, creation, and communication of information that addresses science and technology.

Keywords: scientific literacy, science for citizenship, science education.

Ciencias para la ciudadanía: avances para enfrentar los desafíos de formar ciudadanos alfabetizados científicamente en Chile

RESUMEN

En 2020, la asignatura Ciencias para la Ciudadanía fue incluida en el currículo escolar chileno como respuesta a los desafíos globales de avanzar hacia la alfabetización científica, para incentivar a los ciudadanos a participar en la toma de decisiones para su vida personal o en su participación social. El objetivo de la investigación fue comprender los aportes de la asignatura Ciencia para la Ciudadanía al currículo escolar chileno para avanzar hacia la alfabetización científica.

Este artículo presenta un análisis descriptivo de los documentos de política educativa chilena, a partir de la revisión de los propósitos, enfoques, módulos y objetivos de aprendizaje de la asignatura Ciencia para la Ciudadanía. Los hallazgos muestran que el currículo promueve la adquisición, uso, análisis crítico, creación y comunicación de información que aborda la ciencia y la tecnología.

Palabras clave: alfabetización científica, ciencia para la ciudadanía, educación científica

Ciência para a cidadania: avanços para enfrentar os desafios de formar cidadãos cientificamente alfabetizados no Chile

RESUMO

Em 2020, a disciplina Ciências para a Cidadania foi incluída no currículo escolar chileno em resposta aos desafios globais de avançar para a alfabetização científica para incentivar os cidadãos a participar da tomada de decisões sobre sua vida pessoal ou em sua participação social. O objetivo da pesquisa foi compreender as contribuições da disciplina Ciência para a Cidadania ao currículo escolar chileno para avançar para a alfabetização científica. Este artigo apresenta uma análise descritiva dos documentos da política educacional chilena, a partir da revisão dos propósitos, abordagens, módulos e objetivos de aprendizagem da disciplina Ciência para a Cidadania. Os achados mostram que o currículo promove a aquisição, uso, análise crítica, criação e comunicação de informações que abordam ciência e tecnologia.

Palavras-chave: alfabetização científica, ciência para a cidadania, educação científica.

1. INTRODUCTION

At the beginning of this century, the need emerged to reflect on the educational needs of citizens due to social changes and technological advances that were evident at the end of the 20th century. Thus, the discussion arose about the inability of the structures and the focus of the educational pedagogies preceding the 21st century to deal with the social, economic, technological, and environmental challenges, which have become increasingly complex over time (O'Brien, 2016). Therefore, the debate has advanced concerning the constant societal changes that make the need to address the educational difficulties persisting in the first 20 years of the 21st century more evident. This is partly due to the fact that the traditional or reproductive educational models did not promote the development needed for citizens of the future, ideally represented by “schools that teach content from the 19th Century with teachers from the 20th Century to students from the 21st Century” (Monereo & Pozo, 2001, p. 50). Although progress has been made in proposals that respond to the educational needs of today's citizens, it has become evident that these changes are reaching classrooms at a slow pace.

In this scenario, teaching the science holds a significant role in the acquisition of competencies for citizenship. This is based on the expectation that students will become citizens who can make decisions in their personal and social contexts about issues related to science and that they can confront problems that present themselves in the future (Özden, 2020). For this, it is crucial to help citizens progress to and satisfactory understanding of science. Actually, one of the common objectives of the educational systems of the world is to achieve scientific literacy for students (García-Carmona & Acevedo-Díaz, 2018). School science programs have a leading role in the challenge in forming a literate scientific citizenry that allows students to confront relevant problems that require applying scientific knowledge acquired throughout their school years (Glaze, 2018; Lüsse et al., 2022). Based on this, education has the task of promoting citizen participation in problems related to science and technology connected to scientific knowledge in social and real life contexts with the goal that students understand this knowledge as relevant (COSCE, 2011).

In 2020, Chile began incorporating the subject called Science for Citizenship into the study plans for the student curriculum in secondary education. This course was to contribute to addressing the challenge of channeling interest in science in order to achieve scientific literacy among students. Then, it seems important to refer to the ideas of González et al. (2009) who

proposed that teaching through scientific inquiry could serve as a pedagogical approach that could contribute to scientific literacy for citizens.

2. THEORETICAL FRAMEWORK

2.1 Teaching the science for scientific literacy

The end goal of teaching or education in the science has been changing throughout time. This has been reflected in that education has been extended to different levels of the population, changing the way future scientists are trained to what is promoted today. The goal is to educate the population about scientific issues so that all citizens are aware of the different problems in the world and how they can act on them (Martín, 2002). Acevedo (2017) maintains that the end goal of teaching the science is related to its useful and practical nature related to training citizens to develop abilities for the work world and to continue scientific studies (See Table 1).

Table 1. *Purpose of teaching the science*

Purpose	Description
Useful and highly practical nature	Science knowledge that may be missing for daily life.
Democratic	Knowledge and skills needed to participate as responsible citizens for making decisions about public and controversial issues related to science and technology.
Develop skills learned for the world of work	Team work, initiative, creativity, communication skills, etc.
Propedeutics	Knowledge for continuing scientific studies.

Source: Author's interpretation based on Acevedo, 2017.

One of the goals of science education is to train citizens who have all of the knowledge for understanding and functioning in society while being able to find, select, and critique information that they obtain for transforming society and contribute to its progress (Martín, 2002). Based on this description, Martín (2002) also indicates that to develop these skills, activities can be incorporated into the classroom that are similar to actual contexts and to daily life.

Then, science education is presented as a substantial element to advance scientific literacy for all members of society, regardless of their culture or sector of society they belong to. The goal is to develop in people the ability to

think and reason in order to make better decisions related to new knowledge. That is, the purpose is to contribute to forming citizens who have an opinion based on knowledge and who are capable of making informed decisions in their personal lives as well as in their participation socially. As indicated in the research of Sadler and Zeidler (2009), during the past 50 years, scientific literacy has been recognized internationally as one of the goals of education. This term establishes a metaphorical analogy between basic literacy initiated at the end of the 19th Century and the current movement to make science and technology accessible for all (Fourez, 2005). In this way, when we talk about scientific literacy as science for all, this situates science education as part of general education and, therefore, cultural (Vilches et al., 2004).

That is why we understand that scientific literacy is a vital component of cultural development. It empowers people to make informed decisions, actively participate in a technological society, develop problem-solving and critical thinking skills, contribute to knowledge and innovation, be responsible citizens, and foster a culture of skepticism and open-mindedness. Norris and Phillips (2003) carried out a systematic review of the definitions of scientific literacy, allowing them to organize these into definitions and concepts related to the knowledge and skills it seeks to address. In addition, Roberts (2007), after conducting a review of the existing literature on scientific literacy, proposed two different ways of conceptualizing the term. Version I is conceptualized upon the processes and products of science, while Version II focuses on the relevance of science to everyday life. In general terms, we can say that a difference exists between Versions I and II, based on the idea of a “science for preparing future scientists” versus a “science for all” (Aikenhead, 2007).

Building on these conceptualizations, current scientific literacy must incorporate an understanding of the scientific concepts and principles that underpin the environmental problems we face, as well as the ability to apply this knowledge to promote sustainable practices. Recently, Sjöström and Eilks (2018) proposed Version III, which advances toward a science education for sustainability. This Version III responds to the objective of promoting a science education that goes beyond the scientific knowledge of contents, contexts, and processes. It advocates for the development of general skills based on relevant problems for the sustainable development of our society and the world globally. It is this Version III that we believe is relevant to incorporate adequate scientific literacy in science classrooms, which should have as their objective the teaching of science to form critical, responsible, and committed citizens with the world and the different problems it encompasses (Sequeiros, 2015; Rodriguez et al., 2022).

2.2. Scientific literacy: Building bridges to science for citizenship

Scientific literacy guarantees the incorporation of science and technology into the educational process for individuals. This benefits the development of citizens aware and trained to solve global challenges that confront humanity in reality (Roth & Désautels, 2004; Valladares, 2021). Frequently, the concept science for citizenship is conceptualized and defined within the framework of scientific literacy (Lee & Roth, 2003). This is due to the expectation that knowledge, skills, and attitudes of people scientifically literate contribute to responsible citizens (Jenkins, 1992). To reinforce this idea, when working in subjects for Science for Citizenship, it is important to emphasize the concept of scientific literacy (Barbosa et al., 2004). This emphasis on the degree of understanding of this concept refers to the minimum level of scientific literacy required for any citizen instead of an ideal (Ozden, 2020). It is well known that the acquisition of scientific skills by citizens could lead to the development of citizenship skills, such as the ability to influence approaches that individuals address problems and the skills necessary for making informed decisions about social problems (Barelli et al., 2018).

The work of Blanco (2004) points out that the public understanding of science revisits a social, cultural, and utilitarian need. This implies that citizens need to have some understanding about political, economic, environmental, and cultural networks that involve the development of science and technology in order to understand, influence, and, in ideal cases, propose solutions for everyday problems (Olmedo, 2011). Based on what has been described, a clear relationship can be observed between the challenges confronting the work of science for citizenship with scientific literacy, particularly the consideration that we live increasingly in a globalized world. This needs to be taken into consideration by incorporating into the training processes of people the capacity and commitment to carry out appropriate, responsible, and efficient actions in areas of social, economic, environmental, and ethical-moral interests highly dependent on science and technology (España-Ramos & Resis, 2017). All of this will allow training students how to be critics and creators of knowledge instead of placing them in the role of consumers of knowledge that tends to occur in traditional science pedagogy schoolwork (Bencze & Sperling, 2012), advancing towards the formation of informed citizens with the ability to understand and apply scientific principles, make informed decisions in their daily lives, and actively and responsibly participate in debates and decisions that impact both local and global levels.

Blanco-López et al. (2015) carried out a study with interesting results where they examined the importance of determining characteristics of scientific training desirable for citizens. The authors consulted a group of experts about what knowledge, skills, attitudes, or values of the scientific-technological field needed to form part of the toolkit of every citizen so that he or she could function adequately for different contexts unfolding in their lives. The findings from the study resulted in five aspects that all of the experts consulted agreed upon as relevant: critical attitude or spirit; individual responsibility; ability to search, analyze, synthesize, and communicate information; ability to reason, analyze, interpret, and argue in terms of the phenomenon and scientific knowledge; and ability to work in a team (España-Ramos & Resis, 2017). The purpose of educating citizens to train them in science has been reinforced with the latest changes in the Chilean school curriculum in the last two years of secondary education.

The objective of the research for this article was to understand the contributions of the subject Science for Citizenship for the Chilean school curriculum to advance towards scientific literacy for the population. For this, a descriptive analysis was carried out of official policy documents in order to understand in detail information about the proposed work plan for the subject as it begun to be implemented into the secondary school curriculum in 2020 of the country. This study is relevant due to the needs in societies to actively promote scientific literacy to generate educational policies that guarantee the acquisition of tools for citizens so that they may achieve an understanding and confront the combination of serious problems and challenges facing humanity. Thus, this research sought to respond to the question: How are the purposes, approaches, modules, and learning objectives of the subject Science for Citizenship related to the proposals of scientific literacy?

3. METHODOLOGY

The methodology used for this study was qualitative in nature. The method was descriptive content analysis (Cohen et al., 2007; Selçuk et al., 2014). For the data, information was collected from official public Chilean education policy documents that described the proposal for the subject of Science for Citizenship. This minimized the author's influence on the information analyzed in the study (Elo et al., 2014). The method for analyzing the information collected in the documents was of the manifest or latent type in order to maintain as closely as possible the original description of the data in order to respond to the question that guided this research (Bengtsson,

2016). The documents analyzed included the Curriculum Bases and program of study for the subject Science for Citizenship. The program of this course addresses complex phenomena that require an integrated understanding of science with other knowledge, with the aim of enabling students to use scientific knowledge, skills, and attitudes to make informed decisions, understand real-life situations, and propose solutions to problems that may affect individuals, society, and the environment.

Content from the texts that responded directly to the selected aspects of information was extracted. These aspects included the following: a) *the goals of the subject Science for Citizenship*, which involve analyzing the specific statements regarding the intended achievements during the course; b) *the approaches used for the subject of Science for Citizenship*, which refer to the analysis of the didactic and conceptual orientations of the subject; and c) *the modules and learning objectives for the subject of Science for Citizenship*, which involve analyzing the specific topics proposed in the subject and the learning goals. To carry out the qualitative analysis of the documents, a content analysis matrix was designed to organize and classify the information systematically, favoring the process of reviewing the content of each document in search of the predefined key elements, such as objectives, approaches, and modules related to the topic under study. Each aspect was converted into a category of analysis, and the rows of the matrix represented the corresponding units of analysis within the document.

To carry out the qualitative analysis of the documents, a content analysis matrix was designed to organize and classify the information in a systematically, favoring the process of reviewing the content of each document in search of the predefined key elements, such as objectives, approaches, and topics covered in the course. Each key element became a category of analysis, and the information extracted from the document that responded to each category was incorporated into the rows of the matrix. Finally, based on the content information, the results are presented as a direct and descriptive summary. The data is identified in each aspect selected about the contributions of scientific literacy literature.

4. RESULTS

Goals of the subject.

According to the new Curriculum Bases for secondary education, published by the Ministry of Education during 2019, the purpose of the subject Science for Citizenship is to:

promote an integrated understanding of the complex phenomena and problems that occur in our daily work to train scientifically literate citizens with the ability to think critically, participate, and make informed decisions based on the use of evidence. (MINEDUC, 2019:42)

This subject promotes the integration of interaction of the subjects of biology, physics, and chemistry. These will no longer be treated or be seen as independent, but that their themes or contents will be merged into this new subject. In addition, the science will be related to other knowledge. This will allow students to acquire:

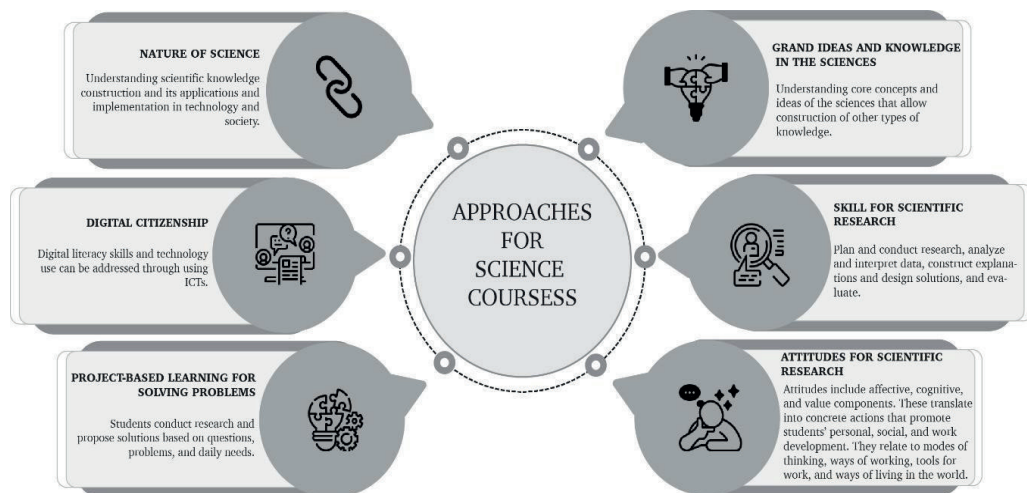
the ability to apply reasoning, the concepts, and procedures of the science to understand experiences and local situations and to propose creative and viable solutions to problems that may affect people, society, and the environment in local and global contexts. (MINEDUC, 2019:42)

The relationship between the descriptions of the goals with the subject and the elements of the scientific literacy literature are observed in the following aspects. These include: an integrated understanding of the phenomena; scientifically literate citizens; ability to think critically, participate, and make decisions; use evidence for decision making; ability to reason in order to understand the environment by using scientific concepts and procedures; and propose creative and viable solutions to societal and environmental problems.

Didactic and conceptual approaches.

The subject Science for Citizenship, as well as all of those of a scientific nature, in the curriculum, presents a series of didactic and conceptual approaches. These have been described in the study plan of the subject. These approaches include the following: the nature of science, great scientific ideas, scientific skills and attitudes, problem and project-based learning, and digital citizenship (See Figure 1). A relationship exists between the didactic and conceptual approaches of the subject with the elements of scientific literacy literature. These aspects include: understanding of scientific knowledge and its applications and implications for technology and society; understand core scientific ideas and concepts; analyze and interpret data; create explanations and design solutions; application of science for thinking, working, and living in the world; generate knowledge based on questions, problems, and daily needs; and develop digital and technological literacy skills.

Figure 1. *Didactic and conceptual approaches of subjects of a scientific nature*

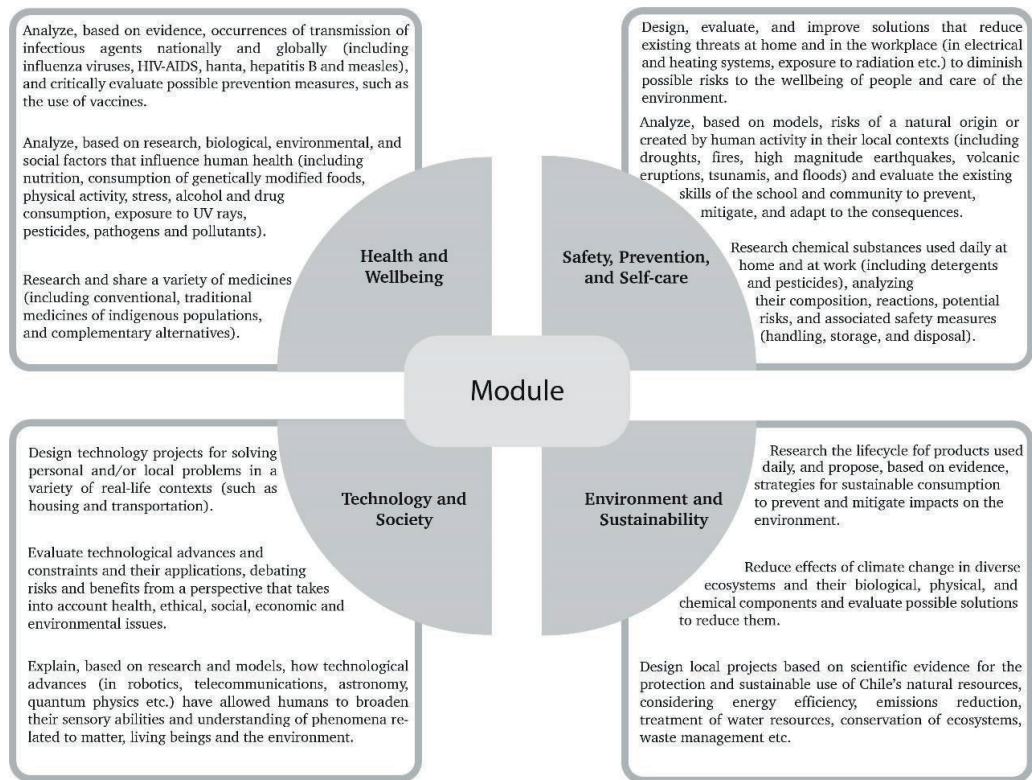


Source: Author's interpretation of MINEDUC, 2019.

Modules and learning objectives.

The subject of Science for Citizenship is composed of four modules. Their duration is one semester. In Figure 2, the modules and learning objectives are presented. In the relationship between the modules of the subject and the objectives of scientific literacy, we see the coherence of the proposed work plan with important themes for citizens. The proposal is to work on issues of a scientific nature that adequately address the context so that individuals value and utilize scientific knowledge to generate informed opinions and viable solutions. It raises working on problems related to health and wellbeing, such as consumption of genetically modified foods, pathogens, and contaminants. In addition, the proposal is to address safety, prevention, and self-care issues, such as medications, pesticides, exposure to radiation, earthquakes, and tsunamis, among others. In the environment and sustainability module, the focus is working on issues of consumption, energy efficiency, and resource management, among others. Finally, the technology and society module proposes designing technology projects and address issues related to robotics, telecommunications, and astronomy, among others.

Figure 2. *Modules and learning objectives for the subject Science for Citizenship.*



Source: Author's interpretation of MINEDUC, 2019.

The relationship between the learning objectives and what is described in the literature about scientific literacy is related to competencies for research. These include: analyzing situations based on research; comparing events in different contexts; analyzing situations based on models; evaluating existing skills for problem solving; proposing strategies and solutions to relevant problems based on evidence; designing projects; explaining phenomena based on research and models; and evaluating advances and limitations of science and technology.

4. DISCUSSION AND CONCLUSION

One relevant purpose of science education is to ensure that citizens achieve scientific literacy. The expectation is that children and adolescents learn the

tools that allow them to apply the knowledge acquired during their education to confront and solve different problems of a scientific nature. To achieve this, the Chilean education system has established different approaches to address the themes of science subjects, such as the ability for wonder, scientific thinking, scientific research, the great ideas of science, scientific literacy, the nature of science, society, and scientific technology, problem and project-based learning, and digital citizenship. These issues are addressed at each educational level from kindergarten to secondary education, progressing continuously in degrees of complexity in such a way as to contribute to the scientific literacy of students from different perspectives and considering their interests.

Each one of these approaches together addresses a deeper level of the new subject of Science for Citizenship. From our point of view, and after analyzing the Curriculum Bases and the study plan of this subject, we can point out that it has the purpose and an adequate conceptual and didactic framework to consolidate scientific citizenship. This develops progressively during all stages of schooling. The different modules proposed in the study plan provide opportunities for applying the scientific knowledge in situations related to global and local problems relevant to the personal and social lives of individuals.

The framework proposed for implementing the subject of Science for Citizenship presents an important opportunity for addressing the challenges that citizens of the 21st Century need to confront in their daily activities, such as controversial socio-scientific issues of interest at the local and global levels. The general action framework proposed for the subject responds to the need to provide tools for decisions people need to take today in their personal lives or their social interactions. These depend fundamentally on the acquisition, use, critical analysis, creation, and communication of information provided by science and technology. The subject of Science for Citizenship implemented in 2020 in the school curriculum in Chile presents elements that are in sync with the challenges of forming scientifically literate citizens who possess knowledge and approaches to make decisions or to understand what is occurring around them.

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