Cultural Studies of Science Education
https://doi.org/10.1007/s11422-023-10190-3

ORIGINAL PAPER

What is meant by scientific literacy in the curriculum? A comparative analysis between Bolivia and Chile

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Received: 3 July 2022 / Accepted: 5 May 2023

Abstract
Scientific literacy is still being identified and recognised as one of the main goals of science education. However, this concept has multiple interpretations and its definition changes continuously depending on its social, cultural, and political contexts. In this paper, scientific literacy is conceptualised through *visions I, II and III*. The first one is focused on the content and scientific processes for its subsequent application; the second, with a focus on understanding the usefulness of scientific knowledge in life and society; and the third one seeks to move towards a politicised scientific education to dialogic emancipation, attending social and eco-justice dimensions. The latter is also called critical scientific literacy. The research aimed at analysing how scientific literacy and these three visions are expressed in school curricula of Bolivia and Chile. Using a qualitative approach and thematic analysis, it is established that the Bolivian curriculum presents mainly a *critical scientific literacy* approach and the Chilean science curriculum presents mainly a *vision II* of scientific literacy. Findings of contrasting both school curricula show science education as non-neutral and profoundly political field, and therefore, we can see relevant opportunities for transformation and emancipation, understanding science curriculum as a social practice.

Keywords Scientific literacy · Science curriculum · Thematic analysis

In recent years, special attention has been placed on the teaching of ´natural´ sciences, whether because their topics intersect with daily life, as in the case of the construction of a personal stance on COVID-19, or because of its articulation with collective positions about socio-environmental issues (Furman 2018). In addition, it is imperative to train more scientists and citizens who are capable of understanding and acting on those situations that require scientific knowledge to be solved (Dillon and Avraamidou 2021). This reality poses the following question: What should the goal of science education be? The answer can

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Published online: 01 August 2023

range from the simple need to transmit scientific knowledge as a way of preserving part of human culture to facilitating the acquisition of the skills that will allow people to critically intervene in their proximal reality (Massarini and Schnek 2015).

At the end of the 1950s, the concept of scientific literacy (SL) was proposed as an answer to the goals of teaching science. SL has been conceived in different ways, focusing on different elements, and becoming a polysemic concept (Özdem, Çavas, Çavas, Çakıroglu, and Ertepınar 2010; Hodson 2011; Massarini and Schnek 2015; Sjöström and Eilks 2018; Balastegui, Palomar, and Solbes 2020). Therefore, when we talk about literacy in science education, it becomes necessary to establish the perspective from which one is addressing it. It is possible to determine *Visions I* and *II* established by Roberts (2007) and *Vision III* by Sjöström and Eilks (2018). The first vision is centred on the scientific processes and content for its latter application. The second is focused on understanding the utility of scientific knowledge in life and society. Finally, the third vision transcends the two previous ones and seeks to promote scientific education that aims at dialogic emancipation and socio-environmental justice. It is fundamental to determining a position on scientific literacy to choose not only the most coherent teaching models or approaches but also to guide the establishment of the scientific knowledge that students must achieve in the classroom, which is normally stated in curricular documents. Therefore, determining a vision for scientific literacy can guide the construction of the curriculum and basic educational hypotheses.

Due to the environmental crisis and its negative consequences, particularly in Latin America, Bárcena, Samaniego, Peres and Alatorre (2020) suggested that consideration should be given to curricular topics on natural sciences that are related to environmental issues and critical thinking skills. However, beyond this, they should also be focused on action and transformation, based on key elements of *Vision III* of scientific literacy. Whatever the vision, the truth is that many countries—including 19 Latin American countries—have addressed the challenge of including the concept of scientific literacy as a core structural element in their school curricula documents (Gil and Vilches 2001; UNESCO 2020). However, there is little evidence and research about how these conceptualisations and *visions* are integrated into the curriculum in Latin America. Additionally, very few studies provide a critical analysis regarding how the economic and political systems of a nation are articulated with the curricular *visions* and hypotheses in scientific literacy.

Therefore, in this paper, we seek to fill this gap. To do so, we analysed the school curricula of Bolivia and Chile. The main reason for selecting these two countries is their very contrasting recent political philosophies. Bolivia, on the one hand, places indigenous communities at a central position in the organisation of a plurinational and social unitary state and the development of a constitution based on interculturality, anti-imperialism, anti-capitalism, and the enshrining of the natural world's rights with equal status for Mother Earth. In the case of Chile, the political system is based on commodification and an extreme neoliberal tendency, installed during 1970s Pinochet's dictatorship. Considering that Bolivia and Chile have very different political hypotheses, the following research question was posed for this research:

> What are the scientific literacy visions present in the school science curricula in Bolivia and Chile?

The general objective of this paper is to analyse and compare the visions of scientific literacy present in the curricula in Bolivia and Chile, and the specific objectives are: (1) to analyse scientific literacy in Chilean school curricula documents, (2) to analyse scientific

literacy in Bolivian school curricula documents, and (3) to contrast and examine the science school curricula *visions* of scientific literacy of Bolivia and Chile, considering their political positions.

This paper is set out as follows. The next section (Section "Scientific literacy") provides an overview of the conceptualisation of scientific literacy, describing and analysing the main visions of the concept. Following this argument, we examine the connection of scientific literacy with curriculum and politics, specifically highlighting the context in which the concept has been developed in Bolivia and Chile. The paper's research methods are then outlined in Section "Methodology", where we describe the data corpora, stages of research, and the process of analysing the curriculum science documents. Section "Findings" presents the results of this research project, with a primary focus on science teaching purposes within science curricula in both countries. Finally, in Section "Discussion and conclusions" we discuss similarities and differences between Bolivian and Chilean science curricula, in conjunction with conclusions about approaches to scientific literacy and its relationship with the political contexts of each country.

Scientific literacy

Arguably, SL is today synonymous with science education (Queiruga-Dios, López-Iñesta, Diez-Ojeda, Sáiz-Manzanares, and Vázquez Dorrío 2020). For many educational policymakers, researchers in science education, and science educators, SL is a fundamental factor in the development of individuals and communities, and it might be even more relevant in times of planetary crises. However, typically, the discourses that address the conceptualisation of SL are closely related to paradigms and ideologies. Moreover, the lack of education in sciences is related to the lack of opportunities and exclusion from political and social discussions about socio-scientific issues that have an impact on the democratic decision-making processes and the insertion of individuals in the current society of information (Fourez 1997; Roth and Barton 2004; Yacoubian 2018). In Latin America, since the 1990s, there has been an intent to place scientific literacy as the core purpose of natural science teaching. This is evident both explicitly and implicitly in the current curricula of the 19 countries in the region (UNESCO 2020).

Nevertheless, the meaning of SL in Latin America is interpreted in multiple ways, and it is a complex conceptualisation, under construction, which has been discussed since the end of World War Two (Balastegui, Palomar, and Solbes 2020; Hodson 2011; Massarini and Schnek 2015; Özdem, Çavas, Çavas, Çakıroglu, and Ertepınar 2010; Shamos 1995; Sjöström and Eilks 2018). This concept is typically associated with the purpose of science education and is often used as a slogan with little clarity about its substance (Sjöström and Eilks 2018; Gil and Vilches 2001).

Vision I of SL: Science for future scientists

This first approach of SL corresponds to what Roberts (2007) called *Vision I*, centred on the conceptual knowledge of science, its internal processes, and methods, promoting a kind of science for future scientists, where science is shown *without* society (Valladares 2021). Therefore, it is expected that through education, there can be a theoretical understanding of the scientific issues of the phenomena considered essential (typically far from daily life), with a focus on the training of future professionals related to the natural sciences

(Massarini and Schnek 2015; Vilches, Solbes, and Gil 2004; Valladares 2021). This way of understanding SL connects the purpose of science education with training aimed at the propaedeutic level (serving as a preliminary instruction for further study in science) or a useful orientation towards the economic growth of nations (Hodson 2011). In this vision of SL, conceptual development or learning the scientific culture is central (Massarini and Schnek 2015), pushing aside issues related to the nature of science, scientific skills, procedures, or attitudes (Hodson 2011). This vision of SL seldom originates or can relate to teaching approaches in which scientific knowledge is useful to understand everyday science or can transition from traditional teaching models towards socio-constructivist ones, which results in a dogmatic and decontextualised teaching of natural sciences (Fourez 1997). This vision of science that is out of context and not oriented towards solving everyday problems or transforming society could be causing the low interest of students in learning natural sciences, in addition to missing out on the opportunity to develop necessary skills for an active life regarding citizenship in democratic systems.

Vision II of SL: Science for all

A second proposal for scientific literacy of SL corresponds to what Roberts (2007) called *Vision II*, which addresses the interrelation between science and how that knowledge is linked to everyday issues, where the aim is the application of scientific knowledge in life and society (Valladares 2021).

Vision II, as proposed by Fourez (1997) and Gil and Vilches (2001), considers that the education of all people should be included ("science for all") so that they can participate in political discussions related to scientific issues. It is stated that science education must be useful so that all can understand the everyday phenomena related to scientific and important social issues (Fourez 1997; Gil and Vilches 2001; Valladares 2021). This is how the teaching of science begins to touch spaces that were not considered by the previously explained vision. From this vision emerges the need to use teaching models that are related to the context of the students and the development of critical thinking skills so students and future citizens can make personal decisions on relevant scientific issues. In addition, this vision explores and looks at the outside of scientific processes, in situations in which science has a role, for example, decision-making on socio-scientific issues or controversies (Roberts 2007), not reaching the point, however, of action or the promotion of activism.

Vision III of SL: Science for transformation

A third proposal includes not only the ability to understand and make personal decisions, but also to build collective actions that allow the solving of real problems (Hodson 2011). This way of interpreting scientific literacy would allow individuals not only to understand scientific knowledge but also to establish values and higher ethics together with others for decision-making (Hodson 2011). This vision is related to the common good and justice and proposes that if weak or fragile scientific literacy is developed, it would contribute to producing technocratic societies in which citizens would not participate democratically in science-related matters (Fourez 1997), and their political systems would become weak. From this perspective, scientifically literate citizens would have power within societies (Fourez 1997). Scientific literacy oriented towards the construction of citizenship has incorporated the notion that scientific knowledge brings power and responsibility about reality with it (Marco-Stiefel 2004). From this perspective, scientific literacy would collaborate with the establishment of

the concept of citizenship. Along the same lines, Marco-Stiefel (2003) considered that education for citizenship should have the purpose of training responsible and autonomous individuals who will actively influence the democratic processes that consider local and global dimensions, and a concern for ecology, pacifism, and solidarity. In this way, with this vision of scientific literacy, socio-constructivist approaches to teaching become coherent, associated with teaching strategies framed within socio-scientific issues (Massarini and Schnek 2015) and collective development that seeks to promote action and activism.

This third vision of SL corresponds to what Sjöström and Eilks (2018) call *Vision III*, which examines how this scientific knowledge is transformed into a critical practice, towards eco-justice, emancipation, and, above all, transformation. According to what is proposed by Hodson (2011), *Vision III* could be collective, and be named a *critical scientific literacy*. It is worth going into depth regarding the conceptualisation of "critical". When referring to this concept, we are talking about the ability to reflect on the world from a transforming and emancipatory perspective of existing hegemony (Hodson 2011; Valladares 2021). Rodríguez (2019) incorporated the idea of conceiving literacy as a critique. When the construction of subjectivities and the transformation of reality are considered, critical scientific literacy should also take on cultural and social transformation. As mentioned by Rodríguez (2019), when making the relation between linguistic and critical scientific literacy, the act of reading is not merely decoding what is written in a text but understanding the relationship the word has with its everyday world. The same would apply to scientific content, where it would not be enough to understand scientific concepts if it does not lead to understanding reality, so the relationship with the context is essential.

Roth and Barton (2004) profile a critical scientific literacy that develops in spaces that seek to break hegemony, generating struggles between groups with different power where they emerge from collective practice. When considering these characteristics of scientific literacy, science is shaped as something closer to the reality of its nature: socially built and determined, changing in the face of new evidence and with consequences for societies (Hodson 2011; Valladares 2021). In relation to its teaching, this vision of scientific literacy brought to the school requires a socio-constructivist approach, with the use of methodologies centred on socio-scientific problems and transdisciplinarity where different disciplines are integrated to search for solutions, using open questions of local and global relevance (Roth and Barton 2004; Valladares 2021). This scientific literacy focusses its implications for teaching distance themselves from a conventional or functional vision, where learning is individualistic, and the individual does not relate constructively to society (Roth and Barton 2004). It becomes evident that in this proposal, the critical scientific literacy configuration established points of encounter between science education, politics, economy, environment, citizenship, and even a moral and ethical dimension.

Finally, the focus of this study is the way in which discourses of school curricula are built, being able, or not, to contribute to providing a structured balance to key learning considered relevant for the education of both scientists and all citizens (Membiela 2002; Vilches, Solbes and Gil 2004). This means that the established vision of scientific literacy determines, at the same time, the logic that should be considered in school curricula documents and the approaches and strategies for teaching and learning natural sciences that would be implemented (Guerrero and Torres-Olave 2022). Therefore, if a change in teaching is pursued, a change of vision in the purpose of teaching is necessary; this is a change in the direction or *visions* of scientific literacy.

Here, school curricula should not only focus on scientific conceptual development, but also on elements such as scientific procedures, the nature of science, and topics about the relationship between science, technology, society, and the environment (Vilches, Solbes,

and Gil 2004). Roth and Barton (2004) added that this curriculum should promote the building of communities that go beyond the school, where knowledge becomes collective and distributed to exercise democratic actions of decision-making regarding topics related to the interests of its members. This would help shape a scientific literacy that is in tune with social and political dimensions and committed to social responsibility service. Therefore, we can establish the need for the construction of a curriculum that aims at critical scientific literacies, that is, that includes critical citizen education, so that doing science will relate in a reflective manner to citizens' local and everyday concerns and issues (Roth and Barton 2004).

Curriculum and politics

The curriculum can be understood according to the words of Gimeno (2010) as follows:

> The cultural content that educational institutions intend to promote among those who attend them, as well as the effects that said content causes in their receptors … its configuration and development encompass political, social, and economic practices, production of didactic resources, administrative and control or supervision of the educational system, etc. (p. 12).

Gimeno (2010) also stated that:

> The curriculum is a text that represents and presents aspirations, interests, ideals, and forms of understanding their mission in a very specific historical context, from where decisions are made and paths are chosen, that are affected by general political options, economical options, belonging to different cultural means, etc. (p. 15).

It is relevant to mention how Gimeno (2010) establishes the direct relationship that exists between the curriculum itself and the important influence that politics has on it. However, each educational process should ask itself what to teach and why it should be taught. Both questions can be answered through the curriculum (Gimeno 2010). Each country organises this knowledge and its purposes in curricular documents that serve as organisers of learning objectives in the teaching and learning processes that teachers will later apply to their practice. Then, the science curriculum is a political hypothesis but also a social practice (Guerrero and Torres-Olave, 2022).

It is necessary to organise what to teach as the first curricular question. From here, different perspectives can arise depending on how the curriculum is understood as an instrument to answer this question, without the need for one to exclude others. This is how the perspective of the curriculum as cultural mediation makes sense for this research; here it is understood that the curriculum is constructed from the social characteristics and tensions of each historical moment, the place in which the purposes of formally schooled education are built (Villegas 2017), and the science curriculum is a product of relationships with politics (Guerrero and Torres-Olave 2022). The curriculum reflects existing power tensions in societies and the dominant values regarding pedagogy and education. Therefore, the curriculum becomes a space of conflict between the different power positions in society, which could result in a replicator or amplifier of the circumstances that determine the power groups (Villegas 2017). From the perspective of the curriculum as cultural mediation, it is possible to establish that it will never be neutral but will be impregnated with

the positions that build it, such as the political positionings that surround its design. Therefore, it is necessary to evaluate the political contexts of the countries that generate science curricula.

Politics and the education system in Bolivia

Bolivia is currently defined as a plurinational state, with an explicitly declared anti-imperialist and anti-neoliberal position (Ducoing and Rojas 2017). The government of Evo Morales marked not only the return of the centre-left but also placed indigenous communities in a central position in the organisation of a social unitary state subject to plurinational law, independent, sovereign, democratic, intercultural, and decentralised. The neoliberal model is substituted by community socialism, and attributions related to territorial autonomies are increased. All of this has been shaped by the frame of constitutionality (Ducoing and Rojas 2017). In addition to this, an educational revolution took place that sought emancipation and decolonisation from an anti-imperialist perspective. This is the result of the collaborative construction of social and ethnic organisations (Ducoing and Rojas 2017). It was included in the education law 'Avelino Siñani–Elizardo Pérez', issued in 2010, which guides towards an education that is revolutionary, liberating, and transforming of unequal social structures and of the nation's productive matrix, an education of resistance to homogenisation, to face the capitalist civilising crisis.

The Bolivian curricular proposal originates from the democratic and cultural revolutionary movement of 2007, from which the productive socio-community educational model derives (Ducoing and Rojas 2019). This model has implied a change in the vision of development of the country, where it is proposed to move from the neoliberal model to a balanced and complementary coexistence based on the plural economy, and greater promotion of social policies, with respect for the environment recognised as Mother Earth (Villafuerte, Romero, Landa, Dávila, Rocha, and Rada 2016). In terms of the production model, this change aims to move the economy from one based on the private sector, which exploits natural resources for export without further consideration for environmental issues, towards a plural economy, controlled mainly by the state, with private, community, and state actors, where natural resources are administered by the state, and which aspires to be an exporter of natural resources industrialised by the state, where food security and energy sovereignty are considered, and where environmental issues have much greater relevance (Ministerio de Planificación del Desarrollo 2013).

Consistently, in the Bolivian secondary education curriculum, we find the following guidelines: (a) holistic and integrating vision; (b) productive vocation; (c) community vision; and (d) decolonisation. These take shape around the natural sciences in the field of Life, Earth, and Territory, a space that seeks to train men and women with critical awareness about living together with the Earth and the cosmos through the development of respectful productive practices of life and environment. The areas that form this dimension are geography, biology, physics, and chemistry (Ducoing and Rojas 2017).

Politics and the education system in Chile

Since the 1980s, with the civic-military dictatorship, Chile has developed a system of commodification and an extreme neoliberal tendency at a political level that has transcended the education system (Bellei and Muñoz 2021). This has continued to this day, despite the

changes that the student revolts of the first decades of the 2000s attempted to bring out introduce (Elórtegui, Arancibia and Moreira 2020; Ruiz, Reyes, and Herrera 2019).

According to Harvey (2005), neoliberalism is:

> a theory of political-economic practices that states that the best way of promoting human wellbeing is to not restrict the free development of capacities and entrepreneurial freedom of individuals within the institutional framework that is characterised by strong private property rights, free market, and free commerce. The role of the government is to create and preserve the appropriate institutional framework for the development of these practices (p. 6).

Neoliberalism affirms that individual freedoms are maintained due to market freedom. The government that is protected by these practices is a neoliberal one, in which freedom is the reflection of the needs of businesses and private property, multinational companies and financial capital (Harvey 2005; Elórtegui, Arancibia and Moreira 2020). The economic model, installed with the Pinochet dictatorship (1973–1990), is also characterised by being highly globalised, with a very small state, where health, education, and social security are merchandise that is traded in the market, contributing to perpetuating the equitable distribution of power and wealth (Hofer 2020). The Chilean economy is characterised mainly by the exploitation and export of natural resources (copper, fishing, wood, agriculture) without productive diversity, which has favoured extraordinary income for large businesses. Although the current government has proposed to diversify the productive and export matrix of the country, with special emphasis on the quality of employment and the protection of the environment (Ministerio de Economía, Fomento y Turismo 2022), this transformation requires ending the subsidiary state and having political representatives who answer to the citizenry and not to economic groups, which becomes complex, given the transversal acceptance of neoliberalism and the control of politicians by economic groups (Hofer 2020).

School has not escaped the neoliberal ideology, giving way to what could be called a neoliberal school. Such schools are characterised by their goal of training individuals for business needs, training the professionals they need, in addition to being controlled by the market. Therefore, the school that used to be public became another service within the economic network, and the freedom for families to choose according to their financial condition was guaranteed, causing an even greater gap in social inequalities (Gutiérrez 2010; Bellei and Muñoz 2021). The globalisation of the neoliberal in education has also resulted in its hypotheses permeating the process of determining educational and curricular standards, and those relate to the purpose of school and higher education (Gutiérrez 2010; Torres 2008). The foregoing has resulted in a highly fragmented, privatised, and socioeconomically segregated school system (Bellei and Muñoz 2021), in addition to precarious conditions for teachers and student learning as a result of work overload, as well as control and excessive curricular content (Melo 2021). Additionally, in recent years there has been an exponential increase in immigration, so the school system, in addition to facing great inequality in the social and economic access to knowledge and opportunity fields (Castillo and Salgado 2018), must also take care of increasing diversity (Silva, Llaña, Maldonado, and Baeza 2018).

The primary and secondary education curriculum in Chile is organised into subjects that must address personal and social dimensions, knowledge, and culture. Proposed learning objectives should allow the development of skills, contents, and attitudes associated with them in each subject. In the case of the science curriculum for secondary education, this is divided into core themes: biology, physics, and chemistry.

Methodology

The present study adopted an interpretative qualitative framework for data analysis. The school curricula for both Chile and Bolivia were analysed using principles of reflective thematic analysis (TA), as outlined by Braun and Clarke (2021). An inductive approach to reflective thematic analysis was adopted to ensure that the themes generated during the analyses reflected the content and inherent themes of the documents. TA was employed for the data analyses for three key reasons: accessibility, flexibility, and logistics. First, unlike other qualitative methods, TA essentially provides users with a set of tools (e.g., practices, techniques, and guidelines) through which they can engage with and interpret their data, allowing researchers to adapt the tools and processes in accordance with the nature of the data and their needs. In the present study, TA allowed for a robust and thorough examination of a large cross-nation data set, summarising the key features while providing a rich, intricate, and detailed account. Second, using an inductive approach allowed the researchers to draw out key inferences from within the data without imposing an external framework (see King 2004). Finally, employing TA allowed the researchers to be thorough while being aware and considerate of temporal constraints. Based on these previous key reasons, TA is useful to contrast two corpora of data (school curricula) from two countries.

To undertake this analysis process, we followed a series of stages. The first phase was related to data familiarisation; in this case, the reiterated reading of the texts in curricular documents of Bolivia and Chile. The second stage looked for relevant data to generate codes, establishing the nodes for this research that relate to the theme of the investigation; the same reference or data could belong to more than one code and the explicit or implicit intention of the data was determined. In the third stage, themes were built around data and codes (nodes), constructing themes in this research. As a fourth stage, there was a review of the logic among themes and their relationship with data and codes, generating theme maps on the purpose of teaching natural sciences and how this was expressed in the declared knowledge to be taught in the Bolivian and Chilean curricula. In the fifth stage, clear names were determined for each theme. In the sixth phase, extracts (references for this research) were selected to relate them to the research question, and finally, in stage seven, this present report was elaborated. A summary of the research stages is shown in Fig. 1.

The data corpora used were the school curriculum documents for natural sciences distributed by the Ministries of Education of Bolivia and Chile. In the case of Chile, the curricular basis from seventh to tenth grade of natural sciences in 2015 was analysed (MINEDUC 2015) and the Natural Sciences Curricular Prioritisation of 2020 (MINEDUC 2020). For Bolivia, the data corpora were the curricular texts: Curricular Basis of 2012 (MINEDU 2012), and Community and Productive Secondary Education, Categorised Study Programmes for Bolivia 2021 (MINEDU 2021). For all the texts, there was an analysis of all ideas that are explicitly or implicitly present in relation to the purpose of teaching the natural sciences. Theoretical support for each document was analysed, as well as the declared positions and knowledge to be taught. The studied educational levels for both countries are those that correspond to students aged 13 to 16, which is equivalent to seventh to tenth grade in Chile and first to fourth years of secondary school in Bolivia.

For this research, reliability was achieved by developing expert peer judgement carried out by the three authors of this paper. We analysed the categorisation and formation of nodes from the studied data and judged them as consistent with the development of themes. The validity of this research was fulfilled thanks to the thematic analysis rigour

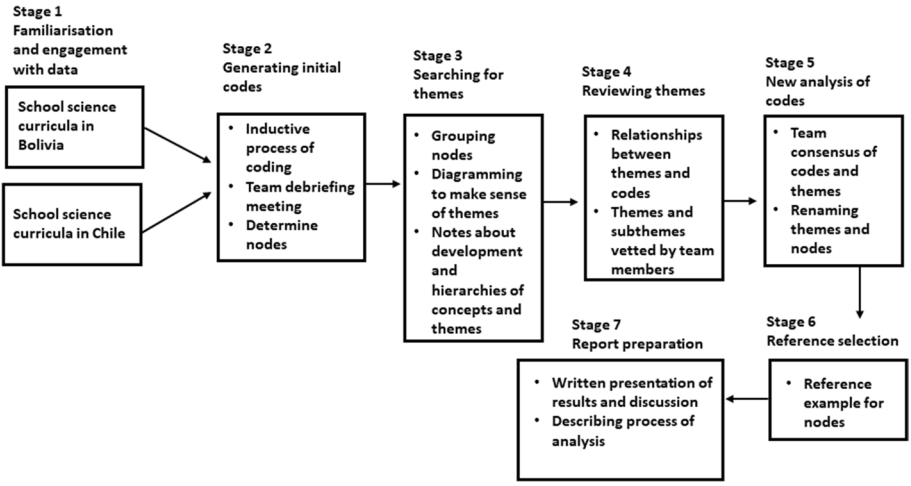

Fig. 1 The stages of analysis for this research were adapted from Braun and Clarke (2021) and Nowell, Norris, White, and Moules (2017), establishing trustworthiness during each phase of the thematic analysis process

that was performed and its later relationship with the existing theory. In addition, triangulation of information sources was developed by considering the theoretical analysis, expert peer judgement, and the analysis of the researcher in relation to the studied data. The thematic analysis was carried out using the tools from the advanced data analysis software, NVivo 12, which allows the categorisation, coding, and organisation of information to be performed.

Findings

The first analysis of documents from Bolivia and Chile considered, in relation to the research questions, the dimensions of the purpose of teaching and what to teach in science. The purpose of the first dimension was to help determine the notions of scientific literacy that underline or are explicit in the curriculum, and the second was how this purpose of teaching science was fulfilled in the types of knowledge that the curriculum proposed as essential for learning science. Students in the school stage were analysed (13 to 16 years).

Science teaching purposes within the science curriculum

The purpose of the science teaching dimension was organised into five themes: (i) characteristics of the natural sciences; (ii) development of curiosity; (iii) integral development of the individual; (iv) knowledge of the natural world; and (v) political or state points of view. Each of these themes is composed of nodes, which are depicted in Fig. 2. It also indicates whether a node is present only in the Bolivian curriculum, in the Chilean curriculum, or in both countries.

Figure 2 shows there are both similarities and differences between what the Bolivian and Chilean curricula propose regarding the purpose of science teaching. Both countries

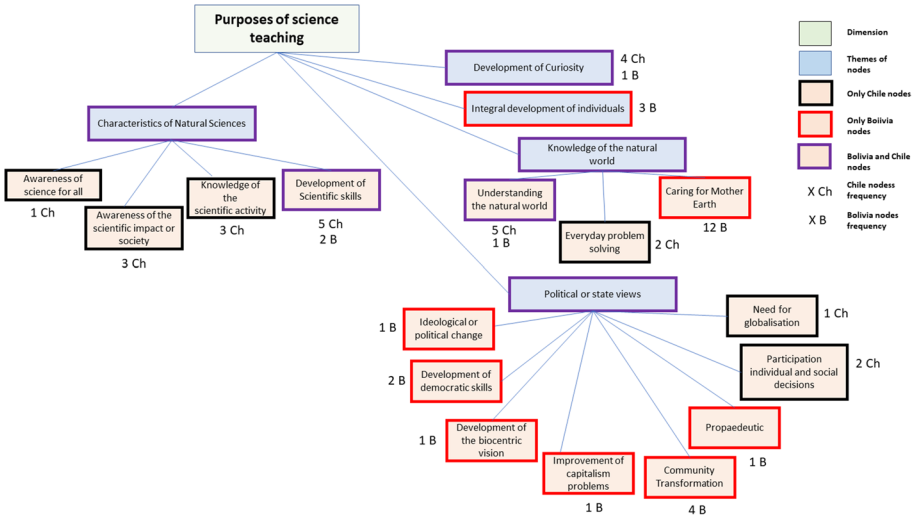

Fig. 2 The organisation of results of the Purposes of Science Teaching (green), themes (blue), and nodes (cream-coloured) of the curricular documents of Bolivia and Chile

show common ground in the purpose of teaching science topics, sharing nodes for purposes related to 'characteristics of the natural sciences', 'development of curiosity', 'knowledge of the natural world', and 'political or state views'. The only theme that is uniquely represented in the Bolivian curriculum is 'the integral development of the individual'. In the theme 'characteristics of natural sciences', the nodes of 'awareness of science for all', 'awareness of the scientific impact on society', and 'knowledge of scientific activity' are only present in Chile. For both Bolivia and Chile, the intention to develop scientific capacities can be identified. The theme 'developing curiosity' is represented in both curricula. Regarding knowledge of the natural world, the 'understanding the natural world' node is found in both curricula, the 'resolution of everyday problems' node is only present in the Chilean curriculum, and 'caring for Mother Earth' is only present in the Bolivian curriculum. In the topic 'political or state perspectives', the 'need for globalisation' and the 'participation of individual and social decision-making' nodes are only present in the Chilean curriculum. The nodes of 'ideological change', 'development of democratic competencies', 'development of the biocentric perspective', 'overcoming the problems of capitalism', 'community transformation', and 'propaedeutics' are only present in the Bolivian curriculum. There are no nodes that are present in both countries. Tables 1 and 2 describe textual references extracted from the curricular documents for each of the nodes.

The Chilean curriculum refers mainly to the nodes of the purpose of science teaching, such as understanding the natural world, developing scientific skills, and developing curiosity (see frequency in Table 1). Then, to a lesser extent, come the related nodes to give meaning to teaching based on scientific impact on society, knowledge of scientific activity, solving everyday problems, participation in individual and social decisions, science awareness for all, the development of ideas about the nature of science and the needs of globalisation. Table 1 shows the definitions and textual references that provide examples for each of these nodes, in addition to the frequencies in which they are present in the curricular documents.

Table 1 Purposes of sciences in the curricular basis of natural sciences for seventh to tenth grades in the Chilean curriculum (MINEDUC 2015)

Node	Description of Node	Reference Example	Number of times referenced
Understanding the natural world	It refers to a textual code where explicit or implicit reference is made to the understanding of the phenomena of the natural world as the purpose of science teaching	"It also emphasises understanding laws and theories that better explain natural phenomena"	5
Development of scientific skills	It refers to a textual code where explicit or implicit reference is made to the development of scientific competencies that involve conceptual, skill and attitudinal knowledge as the purpose of science teaching	"The purpose is that each student develops the ability to use scientific knowledge, applies scientific skills and takes on the attitudes that are inherent in scientific work in order to obtain evidence, assess it and on that basis, keep moving forward in the understanding of the natural world"	5
Development of curiosity	It refers to a textual code where explicit or implicit reference is made to the development of curiosity as the purpose of science teaching	"It is expected that, by observing a great number of close examples, they are encouraged and they enjoy the learning of natural sciences, and their curiosity is strengthened, constantly raising questions about subject-related topics"	4
Awareness of the impact of science on society	It refers to the textual code in which explicit or implicit reference is made to the awareness of the impact of science on society as the purpose of science teaching	"In addition, they discover how scientific ideas contribute to technological changes that have an impact on the manufacture of resources, medicine, and the quality of life of people, and can help to achieve sustainable development"	3
Knowledge of the scientific activity	It refers to the textual code in which explicit or implicit reference is made to the learning of knowledge about scientific activity as the purpose of science teaching	"The curricular basis in Natural Sciences intends for students to learn empirically, what scientific activity implies; in other words, that they acquire scientific research abilities that are common to the exercise of all sciences and that are developed through practice. In this way, they will also understand how current scientific knowledge is generated"	3

Table 1 (continued)

Node	Description of Node	Reference Example	Number of times referenced
Everyday problem solving	It refers to the textual code in which explicit or implicit reference is made to the ability to solve everyday problems as the purpose of science teaching	"… in this way, generate creative solutions for everyday problems"	2
Participation in individual and social decisions	It refers to the textual code in which explicit or implicit reference is made to developing competencies for the participation in individual or social decisions as the purpose of science teaching	"…to be able to participate, in an informed way, in the decisions and actions that have an impact on their own wellbeing and that of the society"	2
Awareness of science for all	It refers to the textual code in which explicit or implicit reference is made to developing awareness that scientific knowledge is a necessity for all people as the purpose of science teaching	"…that they recognise that it is—and should be—available to all people with no exclusions; that they perceive that all individuals need science to survive, to understand the natural world and to make progress in this understanding, whether they work with it at a professional level or not"	1
Need for globalisation	It refers to the textual code in which explicit or implicit reference is made to the fact that, due to globalisation, it is important to develop scientific knowledge as the purpose of science education	"Education in Sciences is an imperative need in a globalised world where technology and innovations have acquired a greater importance"	1

Table 2 Purposes of Sciences in Community and Productive Secondary Education, Categorised Study Programmes of Bolivia (MINEDU 2021)

Node	Description of Node	Reference Example	Number of times referenced
Care of Mother Earth	It refers to the textual code that makes explicit or implicit reference to the teaching of awareness and actions of care or protection of the environmentor Mother Earth as the purpose of science teaching	"In this framework, the current educational model goes beyond the purpose of the provision, teaching love for Mother Earth, to take refuge and be fed by her; but at the same time feed her, protect her and sustain her"	12
Community transformation	It refers to a textual code where explicit or implicit reference is made to the fact that the purpose of science education is to promote changes in society with a vision of community	"Socio-community transformation of students, teachers, the community and the nation"	4
Integral development of the individual	It refers to the textual code that makes explicit or implicit reference to the development of the elements that ensure an integral formation (that does not only involve scientific knowledge) of the students as a purpose of science teaching	"Allow you to have a full and healthy life for the development of all your potentialities"	3
Development of scientific skills	It refers to a textual code where explicit or implicit reference is made to the development of scientific competencies that involve conceptual, skill and attitudinal knowledge as the purpose of science teaching	"To be critical and analytical, questioning, identifying problems and developing creativity and the ability to think differently, so that students have the ability to enquire and experiment, applying the acquired knowledge and skills to solve problems"	2
Development of democratic skills	It refers to a textual code where explicit or implicit reference is made to the need to develop democratic competencies as the purpose of science education	"…territory they develop abilities and practices that arise from doing, from experience and knowledge, that translate into Knowing, developed with values that lead to the practice of attitudes that form the Being, for the making of decisions with the ability and responsibility of deciding in agreement with the community"	2
Biocentered vision	It refers to a textual code where explicit or implicit reference is made to the development of a vision where the biological processes of nature are more central than humans and which must be considered as the purpose of science teaching	"This sense resizes the biocentric view of life centred on the importance of respect, care, preservation, protection and promotion of all healthy lifestyles that interact with balance and harmony with Mother Earth and the cosmos"	1

Table 2 (continued)

Node	Description of Node	Reference Example	Number of times referenced
Improvement of problems caused by capitalism	It refers to a textual code where explicit or implicit reference is made to the search for answers to the problems that have emerged from the economic and political system of capitalism as the purpose of science education	"The field of Life, Earth, and Territory Knowledge [VTT, from its name in Spanish], emerges from the need to transcend the problems unleashed by global capitalism that are affecting life on the planet, beginning with the ecological imbalance, indiscriminate exploitation of nature and the destruction of the fundamental conditions for the reproduction of life"	1
Propaedeutics	It refers to a textual code where explicit or implicit reference is made to the need to train professionals in the area of natural sciences for the development of the country as a purpose of science teaching	"In the scientific areas at a professional level contributing to the technological scientific development of our plurinational state"	1
Development of curiosity	It refers to a textual code where explicit or implicit reference is made to the development of curiosity as the purpose of science teaching	"Geography contributes to the development of abilities, stimulating curiosity in students for understanding their surroundings"	1
Ideological and political change	It refers to a textual code where explicit or implicit reference is made to the need to promote an ideological and political change that varies the conditions of capitalism as the purpose of science teaching	"Takes on the challenge of ideological and political change framed within the cultural education revolution and the process of curricular transformation to respond to the plurinational education system through an education that is de-colonising, communitarian, productive, intra-cultural, intercultural and plurilingual"	1
Understanding the natural world	It refers to a textual code where explicit or implicit reference is made to the understanding of the phenomena of the natural world as the purpose of science teaching	"In this dynamic, Life, Earth, and Territory (VTT) has the Natural Sciences as its component, the same that is part of Biology, Geography, Physics and Chemistry, which foster the development of the necessary pieces of knowledge in a complex way for the explanation, understanding and signification of the relationship between Mother Earth, the cosmos and human beings"	1

The Bolivian curriculum mostly refers to the nodes of the purpose of science teaching, such as caring for Mother Earth, community transformation, integral development of the individual, development of scientific skills and development of democratic skills (see frequency in Table 2). In addition, the nodes with the least representation are biocentric vision, overcoming problems caused by capitalism, propaedeutics, development of curiosity, ideological, and political change, and understanding of the natural world. Table 2 contains the definitions and textual references that exemplify each of these nodes, as well as the frequencies in which they appear in the curricular documents analysed.

Discussion and conclusions

The curriculum prescribed by governments to be taught in schools can be understood as a sociocultural construction that regulates and controls educational practices and expresses in some way the guidelines towards where the training of citizens is to be taken (Ducoing and Rojas 2019; Guerrero and Torres-Olave 2022). There is broad consensus regarding the importance of being scientifically literate in order to fully participate in democracy. The understanding of scientific literacy has gone from a transmissive and propaedeutic vision (*Vision I*) to a vision committed to socio-scientific activism (*Vision III*) (Vilches, Solbes, and Gil 2004; Valladares 2021). From this perspective, scientific literacy becomes a tool for social transformation that requires the participation of all citizens. Scientific literacy, although it seems to be a globally agreed objective, differs in each country in the way in which it is articulated with the idea of citizenship and democratic participation. For scientific literacy to serve democratic processes, and in particular decision-making, students must be able to critically explore socio-scientific problems, as well as the social and economic aspects in which particular social problems based on science are configured. In this way, they will be able to participate in critical deliberation on social issues related to science, being able to question the underlying status quo (Yacoubian 2018).

In this study, when analysing both curricula from the point of view of what their purpose is, we can see that in Chile, the focus is mainly on understanding the natural world, the development of scientific skills and curiosity, and secondarily, understanding the nature of science, and engaging in individual decision-making and problem solving in a globalised world. Thus, and from the perspective of the types of citizenship indicated by Westheimer and Kahne (2004), the orientation of the Chilean curriculum would be between the formation of a personally responsible citizen, that is, a person who acts responsibly towards himself and the others, for example respecting the laws and carrying out acts of charity, and a participatory citizen, with a much more active role in his or her community. Following the example given by the authors, if, under the first vision, a good citizen is one who donates food, in this second vision, the good citizen would be the one who organises the donation.

In the case of Bolivia, the main focus is on the care of Mother Earth, highlighting that the traditions or knowledge of indigenous communities are considered essential. Other relevant elements are community transformation, an individual's integral development, the development of scientific skills and the development of democratic skills. From the point of view of the types of citizenship, the Bolivian curriculum would rather tend towards the formation of a justice-oriented citizen (Westheimer and Kahne 2004), that is, someone who understands the relationships between social, political, and economic aspects. Following the previous example, this vision of a citizen would be that of a person who questions why there are people who go hungry and tries to solve the problem from that understanding.

This is consistent with the analysis of the "political or state views" that support the orientations on the purpose of teaching science. In the case of Bolivia, the political-ideological basis of the curriculum proposes decolonisation as an alternative against capitalist hegemony, through the approach of values and socio-community knowledge of the original peoples, as well as the recognition of cultural identities (Ducoing and Rojas 2019). Although the carrying out of actions or activism-oriented science education is not explicit, through the promotion of the understanding of the relationships between science and productive and political systems, the Bolivian curriculum bets more clearly on a science education that seeks transformational changes to the political and economic world related to neoliberalism and capitalism. This is evident in the clarity with which teaching of sciences must promote "ideological and political changes", "development of democratic competencies", "development of a biocentric vision", "improvement of problems caused by capitalism", "transformation towards the formation of communities", all of which are ideas that go against the ideology that dominates Chile in political and state terms (at the time of this study). Also, observable here is the importance placed in the Bolivian curriculum on materialising the idea that education is politics, and therefore it can be a tool that fosters the status quo or that transforms reality (Freire 2005), moving from an individualistic social conception towards a community one. It is interesting to see how the Bolivian curriculum highlights the "development of biocentric vision", where the centre moves from the human being to nature, something very necessary to change social and governance practices that have led to the current climate crisis.

In relation to the "political or state views", the Chilean curriculum contrasts with the Bolivian one, since there is notorious alignment with the "needs of globalisation" ideas. These views are closely related to the needs of a neoliberal economic model and its expression in education (Elórtegui, Arancibia and Moreira 2020; Ruiz, Reyes, and Herrera 2019). Despite all this, the Chilean curriculum views the teaching of science as relevant to promote competencies to "participate in individual or social decisions", although the desired scope of this is not clear. The question then is whether the expectation is to train individuals who will transform the reality that surrounds them, or whether they are only capable of solving problems while maintaining the established social structures.

This difference between the two curricula in relation to the purpose of science education is interesting, since it expresses two points pointed out in the literature. On the one hand, the Bolivian curriculum breaks with the general trend of traditional school science, offering a narrow vision in relation to diverse worldviews and ideologies, which marginalises, for example, indigenous knowledge about nature (Hansson and Yacoubian 2020). The Bolivian curriculum not only includes indigenous knowledge as an example but also proposes it as a central part of its proposal, being relevant to the context and expanding the possibilities for students to participate in science in a meaningful way for them. On the other hand, the example of the Chilean curriculum points to another outstanding point in the literature, and that is the fact that research on ideologies in science education shows that neoliberal perspectives are frequently communicated, putting the development of the decision-making capacities of future citizens at the service of specific neoliberal agendas (Hansson and Yacoubian 2020).

In light of the scientific literacy *visions* that can be present in the analysed curricula and attending to the initial research question: *What is the scientific literacy vision present in the curricula of Chile and Bolivia?* it is possible to identify similarities and differences between the cases of Chile and Bolivia. In the case of Chile, the stated typical purpose of science teaching is scientific literacy, but there is no description of how it is shaped. This is consistent with the findings of Uribe and Cáceres (2014), who stated that scientific literacy

is scarcely expressed in curricular documents and study texts in the Chilean educational system. Despite this, it is possible to interpret the purposes of the sciences stated in the curricular documents. In this way, it is possible to conclude that the science curriculum in Chile proposes a vision of sciences that is more related to *Vision II*, according to Roberts (2007) and Sjöström and Eilks (2018), where science knowledge is useful to know our surroundings and give answers to everyday problems, but not considering its ability to provide tools for the transformation of reality, along with others. It could be suggested, then, that the way in which the purposes of education in sciences are expressed typically promotes the continuity of the existing structures, allowing the continuation of neoliberal hegemony.

However, according to Magendzo and Gazmuri (2018), there is a certain consensus on the urgency and importance of citizenship training for Chilean students. To do this, the authors propose to move from a curriculum organised around a list of contents expressed as absolute, totalising, and homogenising truths towards a curriculum based on content and complex tensional and conflictive themes that are linked to the political, social, and cultural contexts in which the students perform. Additionally, considering the current social and political crisis in Chile and its intention to resolve this through a Constitutional Convention that writes a new Constitution, it is evident that the conception of scientific literacy of *Vision II* falls short of the current challenges of Chilean society. A more coherent alternative that would also allow us to attempt a curricular change towards coherent orientations and knowledge would be *Vision III* of scientific literacy, which Hodson (2013) describes and problematises as:

> It is generally much easier to proclaim that one cares for an issue than to do something about it. In short, our values have no value until we live them. Rhetorical and proclaimed values will not bring social justice and will not save the planet. We must change our actions. A politicised ethics of caring implies active involvement in the local manifestation of a problem or specific issue, the exploration of the complexity of socio-political contexts in which the issue/problem is located and trying to solve conflicts of interest (p. 8).

In the Bolivian curriculum, scientific literacy is oriented from its intentions towards *Vision III,* according to Sjöström and Eilks (2018), since it clearly suggests the need to address current problems to transform the hegemonic model towards a contextual and community one, consistent with environmental care. In addition, it serves the territory through the knowledge that must be developed.

Comparison between the curricula of both countries is an exercise that can allow us to gain awareness about the ways in which political considerations influence their construction, becoming evidence to be considered when analysing and applying said documents in the educational area, to decide whether it is necessary to keep or change existing conditions at the political, social, or economic levels. The results and conclusions of this research seek to contribute to the analysis and execution of the purposes of natural sciences so that both curriculum experts and teachers determine which are the coherent actions that will allow students to learn what is necessary to become agents of change of reality. This is due to the needs that emerge, such as the current environmental crisis.

From the above, it is clear that political systems influence curricula. However, it is also worth asking whether the implementation of a curriculum can influence political systems. If we assume that the implementation of a curriculum affects the formation of different types of citizens, we could infer that such an influence does exist. However, this will depend on how teachers interpret and implement the curriculum, requiring coherent training with it. For example, the implementation of a curriculum that promotes practices

associated with *Vision III*, such as critical thinking and democratic decision-making, can be affected by teachers' beliefs, such as thinking that science is objective or that it is devoid of values. It also affects the knowledge and awareness that teachers have about the importance of addressing socio-scientific problems, the emphasis they give to different curricular aspects, and the resources they can count on (Yacoubian 2018). From this point of view, it is necessary to understand that the prescribed curriculum needs other actors so that it can be materialised in the classroom, for which the mere existence of a curriculum does not guarantee the effects it intends to achieve.

Our findings show that scientific literacy is a concept that presents itself as an opportunity to show science as non-neutral and profoundly political, and therefore, the teaching of science takes on these characteristics that, if understood in this way, provide important opportunities for transformation, as long as curricular guidelines are combined with the other elements mentioned.

Although this study addressed only some of the educational levels for analysis and compared only two countries, this study could be extended in future research. In addition, the study could be expanded to more countries in the region, to inquire into and examine the *visions* of scientific literacy in relation to their correspondent political systems, and thereby have a greater panoramic view at a Latin American level.

Acknowledgments The authors would like to thank Professor Michael Reiss, Dra. Paulina Bravo and Dr. Iván Salinas who participated in the evaluation and feedback process of this study. The authors are also grateful to the Main Editor and two reviewers for invaluable feedback.

Author contributions A wrote the main manuscript text. B. C. supervised, wrote, reviewed, and edited the main manuscript text. B. Editing and preparing original draft preparation. A prepared figures and tables. All authors reviewed the manuscript.

Data availability Research data policy and data availability statements. The data that support the findings of this study are available from the corresponding author upon request.

Declarations

Competing interests The authors declare no competing interests.

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