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ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/ceer20

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**To cite this article:** Denise Quiroz-Martinez (2024) Chemistry teachers' perspectives and understanding in integrating sustainability into teaching: the case of Chile, Environmental Education Research, 30:3, 432-449, DOI: 10.1080/13504622.2023.2193688

**To link to this article:** https://doi.org/10.1080/13504622.2023.2193688



Published online: 27 Mar 2023.

ENVIRONMENTAL EDUCATION RESEARCH
2024, VOL. 30, NO. 3, 432–449
https://doi.org/10.1080/13504622.2023.2193688

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# Chemistry teachers' perspectives and understanding in integrating sustainability into teaching: the case of Chile

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**ABSTRACT**

Sustainability issues are a problem in Chile because of the policies of the present and previous governments. Chile has a neo-liberal model for development and many ecological problems, which involve social and environmental injustices and an overvalue of economic growth for development. Building on the three pillars model of sustainability of interconnections among the environment, society and economy, this research aims to find out how Chilean chemistry teachers understand sustainability and its integration into teaching chemistry. Data was collected through in-depth interviews with ten teachers and an attempt to highlight teachers' voices about what is possible to do and the impacts of connecting chemistry education and sustainability in the context of a country with a free-market approach to development, such as Chile. Findings indicate that teachers focus on using resources and environmental protection when explaining sustainability and do not relate it to political and economic implications. Teachers confirmed that sustainability integration into education promotes paramount values for living in society and foundational skills for citizenship education, such as critical thinking skills. Nevertheless, teachers focused only on personal actions and attitudes toward sustainability.

**ARTICLE HISTORY**
Received 29 July 2022
Accepted 16 March 2023

**KEYWORDS**
Education for sustainability; education for sustainable development; chemistry education

## Introduction

Education for Sustainable Development (ESD) is a teaching approach rooted in sustainability and promotes values and skills for living sustainably. Specifically, it promotes knowledge of different aspects of sustainability, such as poverty, health, democracy, environmental care, and human rights (Maurer and Bogner 2019; Oe, Yamaoka, and Ochiai 2022). It also promotes skills relevant to citizenship education, such as argumentation, communication, critical thinking and decision-making (Burns 2015; Oe, Yamaoka, and Ochiai 2022).

Chile has a neo-liberalist model for development, which has produced many ecological problems and social and environmental injustices (Temper, Del Bene, and Martinez-Alier 2015). An example of this power of economic elites in Chile is Quinteros and Puchincaví in the Valparaiso region. Approximately 50 industries currently operate in this area - mainly mining companies - and the inevitable accompanying industrial contamination is a problem that has

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affected the area for more than 60 years. Industrial residues and waste have affected not only the natural environment of the zone but also the quality of life of people living nearby whose incomes are below the governmental poverty threshold in Chile. These ecological issues can be related to chemistry, which makes the chemistry classroom a good arena for integrating sustainability into education. ESD in chemistry education allows students to critically discuss and reflect on sustainability issues in Chile and brainstorm viable actions for promoting sustainability in life.

This research explores how Chilean teachers understand teaching chemistry for sustainability in their classroom realities. Building on the three pillars model of sustainability of interconnections between environment, society and economics, I explore and interpret how teachers conceptualise sustainability and its integration into teaching chemistry.

### *Defining sustainable development (SD)*

Meanings for SD and sustainability are 'value-laden' (Fien and Tilbury 2002, p. 3) and diverse (Ávila, 2018; Purvis et al., 2019). It is possible to identify around 300 interpretations of these concepts (Burmeister & Eilks, 2012) and such definitions often contradict each other (Ávila, 2018). The Dictionary, (n.d.), for instance, defines sustainability as actions or activities that can be sustained over. Nevertheless, this dictionary definition also associates the concept with avoidance of the depletion of natural resources in order to maintain an ecological balance. Exponential economic growth, which produces harmful consequences such as pollution, can be sustained over time, but it is not compatible with maintaining ecological balance (Johnston et al.; 2007).

Therefore, it is necessary to consider a broader definition of sustainability and SD, which does not have ambiguous applicability (Johnston et al.; 2007). In the context of this article, the understanding of these concepts is based on nations' economic, political and social priorities and interests (Fien and Tilbury 2002) and promote the balanced relationship among three main pillars: environmental, economic and social (OECD. 2001; Wals, 2009).

Today, the most used meaning for SD is the same suggested by the Brundtland Report, which claims sustainable development is the current development of society according to its needs without affecting the optimal development of future generations (Brundtland 1987). According to the Brundtland Report, SD balances the relations between human needs and Nature's capacity, the needs of poor and rich people and current and future generations' needs. Therefore, SD simultaneously promotes social equity and economic equality within and between nations and aims to protect and preserve the natural environment (Blewitt, 2008).

According to OECD. (2001), balanced interactions between these pillars and their consequences can be (see numbers in Figure 1):

1. From the environment to the economy: instrumental functions of natural resources.
2. From the economy to the environment: investment in environmental protection.
3. From the environment to society: negative consequences of environmental degradation on human health.
4. From society to the environment: citizens' environmental awareness.
5. From the economy to society: the importance of social agreement for market transactions.
6. From society to the economy: living standards and employment opportunities.

However, the current dominant conceptualisation of SD has an anthropocentric perspective. It tends to overvalue economic growth as development and involves social and environmental injustices (Kopnina 2012). Uninterrupted economic growth promoted by the global economy has caused critical ecological and social issues such as water and soil pollution and climate change (Räthzel and Uzzell 2009).

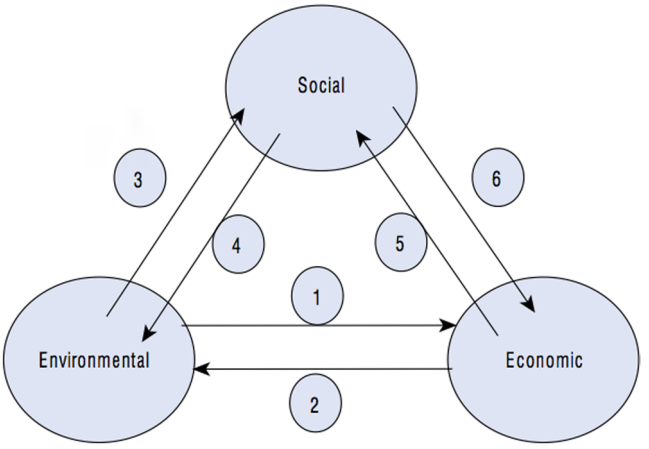


**Figure 1.** The three pillars model for sustainability (OECD. 2001; p. 37).

In Latin America, Chile was the first to embrace a neoliberal model for economic growth after Pinochet's military coup on the 11th of September 1973 (Harvey, 2005). The neoliberal economic model promotes individualism, privatisation of public assets and social security, and opening of natural resources to private investment without any regulation of exploitation and free-market trade (Solimano 2012).

In Chile, there is a lack of government regulations concerning environmental protection through industrial work. The uncontrolled pollution produced by industrial processes affects not only the health and quality of life of people living nearby whose incomes are below the governmental poverty threshold in Chile but also destroys the habitats of flora and fauna. According to the Global Atlas of Environmental Justice (Temper, Del Bene, and Martinez-Alier 2015), Chile is in the top ten countries with environmental issues worldwide. The lack of power that the Chilean government has in decisions involving economic, social and environmental issues is due to international market agreements and corporate elites being more powerful than the nation States themselves (Jickling and Wals 2008).

## *Understanding education for sustainable development*

Early environmental education focused mainly on explaining to learners how human actions affect the biophysical environment (Gough 2014). Nevertheless, educators agreed that it was also necessary to include learning skills and values related to environmental awareness (Tilbury 1995). Thus, it was necessary to have an education for the environment rather than education about the environment (Thomas 2009). It was to promote the teaching of values needed for sustainable living (Tilbury 1995).

At the end of the 1980s, ESD replaced Environmental Education as the central discourse in international political conferences (Stevenson 2014). This shift was because education was recognised as a fundamental tool to promote sustainable development, which could be accomplished by improving people's skills to address developmental and environmental issues (Gough 2014). It was not only necessary to understand different aspects of sustainability, such as poverty, health, democracy, human rights and others but also to support learners in developing relevant skills for citizenship education, such as argumentation, critical thinking and decision-making (Sjöström, Rauch, and Eilks 2015). It is to promote ESD competencies (Herranen, Yavuzkaya, and Sjöström 2021).

Within the field of Environmental Education, some authors and educators prefer to use the concept of Education for Sustainability (EfS) rather than ESD. Sustainable Development has been directly related to the economic growth of nations, has an excessive instrumental orientation,

and lacks personal, cultural and value dimensions (Stevenson 2014). For example, some authors agree that SD is an empty signifier that works as a myth promoting transitory salvation discourses but has no intrinsic meaning since sustainable development founded on economic growth is unsustainable (Jickling and Sterling 2017).

Since this research does not aim to explore how or why teachers understand ESD and EfS differently or similarly, this study uses both concepts interchangeably, as other authors do (e.g. Walshe 2017). It is an education that promotes knowledge of different aspects of sustainability, such as human rights and social and environmental justice (Oe, Yamaoka, and Ochiai 2022). It supports learners in learning to know, learning to be, learning to live together, learning to do, and learning to transform oneself and society (UNECE, 2012).

Therefore, ESD is holistic and involves learning about sustainable content and fostering skills and values for creating a sustainable society. ESD pedagogies are place-based, experiential and interdisciplinary and encourage learners to question, challenge and critically reflect upon current sustainability issues (Birdsall 2014). It aims to empower learners to question societal actions that have led to sustainability issues and challenge their worldviews to promote social transformation (Shwartz *et al*. 2020). This transformation is related to changing how people interact with and affect the environment and transforming societal consumption and production as linked to sustainability issues (Wals and Benavot 2017).

Various authors associate the integration of sustainability into teaching and education with the quality of teaching, which adds considerable responsibility to the already complicated role of teachers (Leal Filho *et al*. 2018). However, teachers still admit to a lack of knowledge of sustainability and its integration into education (Birdsall 2014; Burmeister, Schmidt-Jacob, and Eilks 2013; Birdsall 2015; Ferreira *et al*. 2019). Hence, developing ESD is a challenge, considering that teachers have a crucial role in promoting sustainability through education.

### *ESD in Chile*

The Chilean government argues that education has a paramount role in promoting SD because it facilitates both the transmission of knowledge and allows students to develop skills that will support them in changing the future (Chilean Ministry of Environment 2009). Also, it states that teachers should address a pedagogy that fosters cultural transformation towards a sustainable society. Hence, this official document confirms that teachers have a crucial role in promoting sustainable development through education. For example, the recently published Chilean Teacher Training Standards (MINEDUC 2022) confirm:

> Science is understood as a process of construction knowledge of phenomena in the natural world, based on empirical research and influenced by sociocultural factors and, through the analysis of its purposes and fields of application, the use of models and the execution of projects, contributes to the formation of scientifically literate citizens who are committed to sustainable development (MINEDUC 2022, p. 77).

These standards suggest that science teachers (chemistry, biology and physics) must support learners in developing a commitment to sustainable development. Therefore, chemistry education plays a crucial role in SD.

In Chile, the concepts of sustainability and protection of the environment are included on the National Curriculum, specifically in subjects such as History (and Social Sciences) and Science (MoE, 2009). For instance, the Chilean national curriculum confirms that chemistry teacher should:

> [Chemistry teachers] motivate their learners to design and participate in collaborative projects to address contingent problems and promote learners' commitment to citizenship values necessary for sustainable development and environmental care (MINEDUC 2012; p. 227).

This official document narrows chemistry teaching to developing just one pedagogical approach to integrating sustainability: developing collaborative projects. It is not clear how chemistry teachers, through these actions, can support students in engaging and participating

in democratic processes and sustainable development, nor it is clear how chemistry teachers can develop such a 'collaborative' perspective for promoting ESD.

Chemical principles are necessary for comprehending current sustainability-related issues such as principles for renewable energy technology, single use plastics, among others (Shwartz *et al*. 2020). For example, through chemistry education, students can understand how chemical developments are connected with and affect the social, environmental and economic pillars of sustainability (Herranen, Yavuzkaya, and Sjöström 2021). However, the integration of sustainability into chemistry education should focus on more than just supporting students to become responsible consumers or helping them question their personal decisions concerning the use of products (e.g. biofuels, plastics) and its consequences for the environment and society. ESD in the context of chemistry education also needs to have a socio-political perspective (Herranen, Yavuzkaya, and Sjöström 2021).

To promote this integration, teachers need to understand what sustainability means in the first place. How can teachers integrate sustainability into their practice if they have yet to reflect on and develop an understanding of this concept? This research explores Chilean teachers' understanding of sustainability and its integration into chemistry education.

## Research methodology

This research is rooted in a qualitative methodology and attempts to portray what particular people do in their daily life contexts and what their actions signify for them (Erickson 2018). Understanding teachers' interpretations of the experience of teaching chemistry and their conceptualisation of sustainability are fundamental to comprehending their ideas on sustainability integration into chemistry education.

Hence, this research is built upon an interpretative approach (Danermark, Ekström, and Karlsson 2019; Shaw 2019) and aims to address two research questions: (1) How do Chilean chemistry teachers conceptualise sustainability? (2) How do they understand the integration of sustainability into chemistry teaching?

This study explores how a particular experience is understood by those experiencing it, therefore, purposive sampling was useful for this study (Smith and Osborn 2008). I interviewed ten chemistry teachers with at least six years of teaching experience in secondary schools in Chile. Individual semi-structured interviews were one hour long.

My study adhered to BERA's (2004) ethical guidelines. Participation and data were confidential, and information obtained was used only for this research, to be destroyed afterwards. Opinions, knowledge and practices were not categorised as correct or incorrect.

According to Jickling and Wals (2008), teachers' ideas on ESD relate to their educational and citizenship perspectives. Hence, I created an interview schedule for exploring teachers' interpretations of their experience as chemistry teachers, their ideas on sustainability and how they conceptualise the integration of this term into their practice considering the realities of their classrooms. Interviews were carried out in Spanish, the native language of the participants and the researcher. Sharing the same language avoids communication issues (Esposito 2001) and helps me interpret teachers' ideas and experiences.

Data analysis was carried out through inductive and deductive approaches for thematic analysis (Shaw 2019). Firstly, through the inductive approach, I analysed data line by line and identified themes and codes relevant to RQ1, considering only the participants' ideas. Using a thematic approach, I began to analyse interview data by reading each transcript several times in order to understand its meaning (Lindseth & Norberg, 2004). I read teachers' ideas about sustainability and identified what aspects they associated with sustainability, without trying to impose the 3 pillars model to their views. By performing this initial reading (naïve reading, according to Lindseth & Norberg, 2004), I started to immerse myself in data: reading it and looking for meanings and patterns in the ideas expressed by teachers during interviews. Through this initial description of

the data, I began to identify various topics mentioned by teachers during our conversations when describing their pedagogical experiences. For example, I recognised issues they identify in teaching chemistry for sustainability, what feelings are expressed during the interview and the impacts they recognised when teaching for sustainability, among others.

Second, it is 'interpretive coding' (Shaw 2019, p. 191). It involves an initial interpretation of how participants shared events, beliefs, values and ideas during the interview to help me understand their experiences (Shaw 2019). To develop themes from the codes, I combined making sense of what teachers said and my experience and knowledge in the Chilean educational system. Knowledge about teachers' pedagogical experience in Chilean classrooms supported me in understanding the needs and problems they identified from their practice.

Later, I adopted a deductive strategy for interpreting teachers' ideas on sustainability by looking at the themes and codes I had identified through the lens of the 3 pillars model for sustainability (see Figure 1) and current literature in the field.

The limitations of this research must be acknowledged. I only interviewed ten secondary school teachers. Future research may benefit from a more intensive methodological design, including more participants. Also, I recognise the limitations associated with possible self-selection of participants, which may bias my findings. Those teachers who agreed to participate in this study did so because they were interested in its topic. This aspect imposes restrictions on extrapolating my findings to other teachers working at the same or other schools.

Nevertheless, I recognise by adopting a qualitative approach for research it was not my aim to generalise the findings of this research. This study attempted to find out the lived experience, or the phenomena (Cohen, Kahn, and Steeves 2000): how participants conceptualise and experience integration of sustainability into their practice, based on how they perceive the experience of teaching chemistry and teaching broadly.

I also recognise the effect of translation from Spanish to English as a limitation. I acknowledge that interview translation involves a cultural aspect because language interpretation is directly associated with geographical and cultural factors (Filep 2009). Hence, due to cultural and grammar differences between English and Spanish, I used the meaning-based interpretation rather than word-for-word interpretation (Esposito 2001) to prevent data loss.

## Findings

### *Teachers' ideas on sustainability*

All ten teachers claimed to be unsure about what sustainability was. Although they recognised the importance of integrating sustainability into education, most confirmed they needed more knowledge. For this reason, during interviews, I explicitly claimed I did not want to evaluate their knowledge about this term but to understand their perspectives and ideas. When asking teachers for words they associated with sustainability, they cited various concepts such as 'environment', 'green areas', 'ecology' and 'organic'. The words that they mentioned the most were 'resources' ('recursos' in Spanish); 'environment' ('medio'/'ambiente' in Spanish) and 'waste' ('desechos' in Spanish) (see Figure 2).

When asking teachers to identify words associated with sustainability, they confirmed concepts such as environment, use of resources and waste. Since I am native in the same language as the participants and a Chilean chemistry teacher, I was able to capture a wide range of subtle meanings that may not be explicitly disclosed to someone unfamiliar with the language and the Chilean educational context. Some terms or expressions used by teachers are informative in themselves, adding nuances to what is reflexively said. For example, considering the following quote:

> **T9:** In Chile, [chemistry teaching] is mainly taught theoretically inside a classroom [not using labs]. Yes, because I see now in schools that teaching chemistry is mainly focused on supporting students to pass

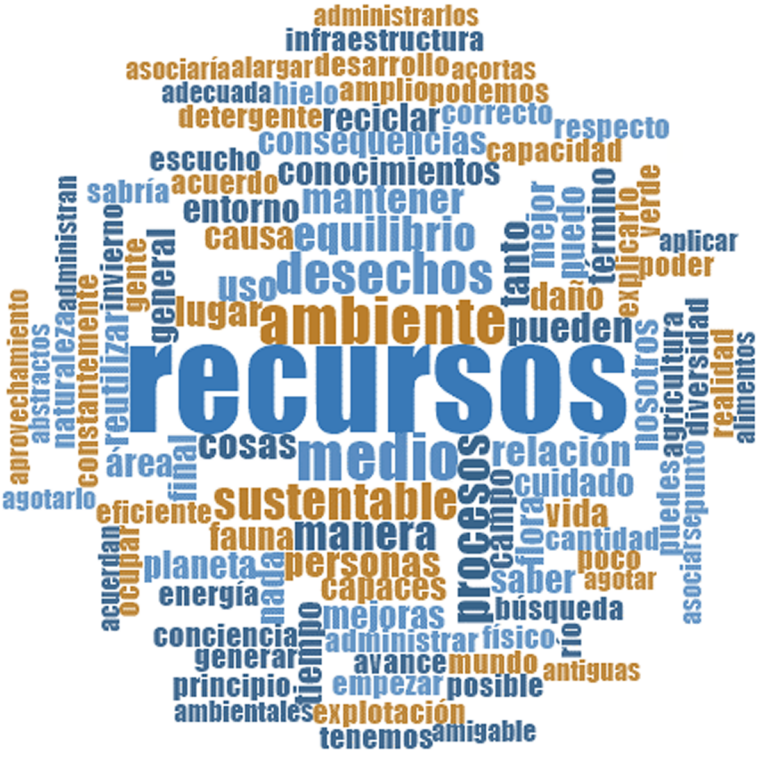


**Figure 2.** Word frequency cloud for teachers' ideas on sustainability.

> national exams. It is to get curriculum coverage. In the end, you give all the content from the curriculum. But what do students learn? They learn much less than what we transmit from the curriculum.

In this quote, I recognise that the idea of 'transmit content from the curriculum' is commonly used by teachers to explain the idea of presenting all contents that are evaluated in national examinations (e.g. national exams for accessing the university) to students without a critical reflection on these topics. It tends to be reduced to presenting these contents as knowledge that students should memorise to pass national exams. As teacher 9 confirmed, 'transmitting' content to students does not necessarily mean they learn it (e.g.'They learn much less than what we transmit from the curriculum').

Therefore, to develop themes from the codes, I combined making sense of what teachers said and my experience and knowledge in the Chilean educational system. Knowledge about teachers' pedagogical experience in Chilean classrooms supported me in understanding the needs and problems they identified from their practice. However, a big challenge was to try to keep these original subtle meanings and nuances, given that I am neither native in English nor a professional translator.

While analysing teachers' interviews, I noted that their understanding of sustainability was linked to two main themes: 'developing personal actions and attitudes for sustainability' and 'human existence depends on Nature'. In the following sections, I portray and describe these themes and present relevant data used in their construction.

### *Developing personal actions and attitudes for sustainability*

All teachers described sustainability as actions and attitudes that a person adopts to promote sustainability. These actions and attitudes are related to three sub-themes: 'effective use of

**Table 1.** Sub-theme 'Effective use of resources'.

| **Sub- theme:** Effective use of resources (ideas mentioned that are related to the use of resources when a person looks for sustainability) | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 | T10 |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Positive: what it should be promoted when using resources (in relation to sustainability)*** | | | | | | | | | | |
| 1.- To keep its use over time | | ✓ | | | ✓ | | | | ✓ | |
| 2.- To take advantage of it | | | | ✓ | | | | | | |
| 3.- Availability of/generation of it | | | | | | | ✓ | | ✓ | |
| 4.- Proper managment | ✓ | | | | ✓ | | ✓ | | | |
| 5.- To improve resources | | | | | | | | | ✓ | |
| ***Negative: what it should be avoided when using resources (in relation to sustainability)*** | | | | | | | | | | |
| 1.- To damage the flora and fauna | ✓ | | | | | | | | | |
| 2.- To lose resources | ✓ | | | | | | | | | |
| 3.- Over-consumption/over-exploitation | ✓ | | | | ✓ | | | | | |
| 4.- To exhaust resources | ✓ | | | | ✓ | | | | | |
| 5.- To damage humanity | | ✓ | | | | | | | | |

**Table 2.** Sub-theme 'Reducing contamination'.

| ***Theme:****Developing personal actions and attitudes for sustainability* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sub- theme:** Reducing contamination | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 | T10 |
| ***1.- Contamination:****ideas mentioned about contamination when a person looks for sustainability* | | | | | | | | | | |
| a.-Do not contaminate | | | | ✓ | | ✓ | | | | ✓ |
| b.- Do not produce residues/waste | | | ✓ | | | | ✓ | ✓ | | |
| c.- To reduce residues' production as lower as possible | | | ✓ | | | | | ✓ | | |
| ***2.- Waste treatment: how waste should be treat when a person acts for sustainability*** | | | | | | | | | | |
| a.- Recycling | ✓ | | | ✓ | ✓ | ✓ | | | | |
| b.- Reuse residues | ✓ | | ✓ | ✓ | | | | ✓ | | |

**Table 3.** Sub-theme 'Positive attitudes and actions towards the environment'.

| ***Theme:****Developing personal actions and attitudes for sustainability* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sub- theme:** Positive attitudes and actions towards the environment | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 | T10 |
| 1- To respect the environment | | | | | ✓ | | | | | |
| *2.- Environmental awareness (to know the consequences of your actions over the environment)* | ✓ | | | | | ✓ | | | ✓ | |
| *3.- Actions towards the environment* | | | | | | | | | | |
| a.- To protect the environment | | ✓ | | | | | | | | ✓ |
| b.- Do not damage the environment | ✓ | | ✓ | ✓ | | | ✓ | ✓ | | |
| c.- Actions for extending the life of the planet | | | | | | ✓ | | | | |
| d.- To promote positive relation between the environment and humans | | | | ✓ | | ✓ | | | ✓ | ✓ |

resources' (see Table 1[1]), 'reducing contamination' (see Table 2), and 'positive attitudes and actions towards the environment' (see Table 3).

Six teachers asserted that sustainability was about using resources efficiently, which, according to them, meant for example managing their use over time and avoiding the over-use of resources (controlled use).

> T5: … [sustainability] is to use any resource, maybe, in a responsible way… without overexploiting it, allowing it to be used constantly.

Teachers used the concept of '*resource*' in different ways. For example, some teachers associated it with natural resources, others talked about resources from the local community (e.g. spaces and materials), and only one teacher related resources to non-material components such as skills and knowledge:

> **T7:** I associate that word [sustainability] mainly with the use of resources, which can be financial resources, as well as abstract resources such as knowledge and soft skills. It means using these resources in the best way possible… based on this proper use, we can get a place with better conditions, for example a better infrastructure, and improve the quality of life of people from that area.

According to teachers, the effective management of resources also means producing new resources (e.g.'*to take advantage of*' and/or '*to improve*') to support communities or societies and improve their quality of life. For example, four teachers mentioned the idea of creating a garden at the school, which is linked to sustainability in the sense that it allows for the generation of natural resources (e.g. vegetables) for the community and makes the most of available space inside the school.

Teachers described reusing waste, avoiding its production or recycling it as actions for sustainability at a personal level. Eight teachers mentioned that sustainability was about taking personal action (e.g. what I can do) to reduce environmental contamination, such as recycling or reusing waste:

> **T4:** It [sustainability] is how I can do different processes without generating… I do not know if it is the proper word but 'any waste'… to produce the minimum amount of waste as possible.

> **T6:** [A]s I said before, when you asked me about sustainability, I think about contamination… like how I can avoid it [contamination].

Personal actions for sustainability mainly focus on activities that promote environmental care and protection. All teachers stated that sustainability was about people being aware of the consequences of their actions for Nature (which I associate with environmental awareness). When describing sustainability as 'the effective use of resources', eight teachers explicitly asserted that these actions had to avoid causing any damage to flora and fauna:

> **T1:** it [sustainability] is to be aware of what you are doing… for example, if I flush detergent into a river, I have to know what the consequences are of doing so.

> **T6:** For me, sustainability is what I can do to keep the planet Earth alive. It is to extend its [planet Earth's] life.

No teacher mentioned, for instance, what industrial responsibility (e.g. the copper mining industry in Chile, in Quiroz 2019) should be for effectively using resources, protecting the environment and/or reducing pollution. For example, they did not talk about political or economic actions that can impact environmental preservation or degradation (OECD. 2001).

### *'Human existence depends on nature'*

Understanding teachers' ideas on sustainability by using the lens of the three pillars model for sustainability means recognising that their ideas are mainly related to the interconnection between the social and environmental pillars. To understand this interconnection, I identified that teachers described the ***implementation*** of human actions and attitudes for sustainability from a personal perspective (individual realm) alone (e.g. what 'I can do').

By reading interview transcripts as a whole document and reflecting on the main theme 'developing personal actions and attitudes for sustainability', I identified another main theme, which described reasons teachers cite for promoting personal actions and attitudes such as environmental protection and the correct management and use of resources.

All teachers justified actions and attitudes toward sustainability from a societal perspective. Their ideas for explaining the reasons for promoting personal actions and attitudes toward

**Table 4.** Theme 'Human existence depends on Nature'.

| ***Main theme:*** Human existence depends on Nature | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sub-themes | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 | T10 |
| 1.- The planet Earth is the place for human existence | | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | |
| 2.- Nature has resources necessary for human existence | ✓ | | | ✓ | ✓ | | ✓ | | ✓ | |
| 3.- Balanced relationship allows human and Nature wellness | | | | ✓ | | | | | | ✓ |

sustainability are related to the idea that 'human existence depends on Nature' (see Table 4). I inferred this collective perspective based on how teachers spoke about the effects of actions for sustainability: they referred to 'our', 'humanity' and 'living beings'.

Based on teachers' ideas, I can identify two views that explain humans' dependence on Nature. Firstly, it is related to the notion of 'using' the environment (or Nature) for human subsistence. Nine teachers confirmed it is fundamental to keep the environment clean and avoid over-exploiting its resources because it allows humans to exist (current and future generations), and the Earth is the place for humans to live. This view is directly associated with an anthropocentric perspective of environmental protection (Kopnina 2012).

**T4:** […] our grandchildren will not have a planet to live on.

**T2:** Natural resources that we [humans] have are finite. So, we have to take care of them.

The second view for explaining humans' dependence on Nature is, according to teachers, related to the idea of 'balance' ('equilibrio' in Spanish, see Figure 2). Only two teachers stated that maintaining the natural balance of the environment was necessary because there is a direct relationship between human well-being and environmental well-being. It allows us (humans) to be well and live well. Their ideas regarding sustainability relate to the importance of protecting the environment since it means acting for the common good of Nature and humans (Kopnina 2012):

**T10:** [Sustainability] is about realising our lives [human life] does not only depend on our bodies. It is also related to what is around us. Everything that is around us [the environment] is super important for [human] development. So, when [the environment] is in good condition, we can balance the relationship between organisms, that means us [humans], and the environment.

In summary, teachers' ideas regarding sustainability are related to actions and attitudes toward sustainability. On the one hand, teachers link the implementation of such actions and attitudes mainly to individual/personal activities (individual perspective). In other words, actions (such as efficient use of resources or reduction of pollution) and attitudes (e.g. environmental awareness) are explained by teachers from a personal view: what a person can do *for sustainability* (see Figure 3). On the other hand, teachers associate the impacts and consequences of

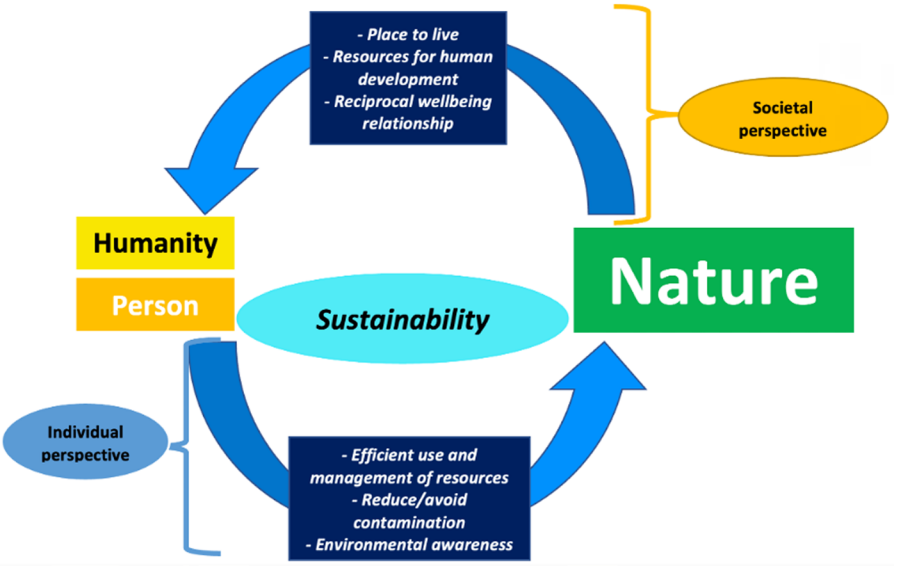


**Figure 3.** Teachers' ideas on sustainability.

sustainability actions with humanity and all living beings (societal perspective), since humanity depends on Nature. In other words, they described the positive and negative impacts of the personal actions *for sustainability* from a collective view: the consequences of such actions affect all of us, the humanity (see Figure 3).

### *Teachers' ideas regarding integrating sustainability into chemistry teaching*

As presented in the previous section, teachers admitted lacking knowledge of sustainability. In this context, they also confirmed lacking experience in integrating sustainability into education similar to that noted in other parts of the world (e.g. Burmeister, Schmidt-Jacob, and Eilks 2013). Hence, during the interviews teachers shared with me their perspectives on what they think such integration is about.

As teachers perceived that sustainability relates primarily (but not exclusively) to the environmental pillar, most of them associated sustainability integration into chemistry teaching with supporting students in developing 'environmental awareness' (see Table 4). Teachers identified that ESD in the context of chemistry education is about 'supporting students in developing skills and attitudes for living responsibly in society'. This theme and its sub-themes are described in Table 5.

Seven teachers associated sustainability integration into chemistry teaching with supporting students in developing 'environmental awareness'. All teachers linked it to assisting learners in reflecting critically about their actions' impact and helping them gain an awareness of the current environmental crisis (Reid *et al*. 2021). They confirmed that promoting critical thinking in the context of ESD means helping learners think of ways to collaborate to resolve current environmental problems, hence linking critical thinking to decision-making skills (Zeidler and Keefer 2003).

> **T3:** I think [chemistry education for sustainability] is about valuing the environment. It is to help [students] to understand our current problems [environmental problems] and realise that through small changes they can collaborate to solve it [environmental issues]. They can help to solve it even if only by using fewer plastic bags.

> **T4:** It is to support [students] in getting analytical, to be able to evaluate situations. It is about [students] being able to recognise which situations can cause more damage to the Planet. I think it [teaching chemistry for sustainability] is to promote a conscious teaching and learning […] when we promote a conscious teaching and learning, students will develop almost all skills […] Teaching chemistry for sustainability is about supporting students to be aware of what they are doing and its effects on the Planet.

> **T10:** I think [chemistry education for sustainability] is related to care of the environment… and being responsible for it. Maybe, something else that is important, it is to become responsible for our own actions, how we eliminate our waste.

All teachers confirmed that integrating sustainability into chemistry teaching enables them to support learners in thinking critically about the impact of human activity on Nature and

**Table 5.** Theme 'Supporting students in developing skill and attitudes for living in society'.

| ***Main Theme:****Supporting students in developing skills and attitudes for living in society* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sub-theme:** Developing Skills | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 | T10 |
| 1.- *To think critically* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 2.- *To work as a team (take agreements)* | | ✓ | ✓ | | | | ✓ | ✓ | | |
| **Sub-theme:** Developing Attitudes | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 | T10 |
| 1.- Being tolerant | | ✓ | | ✓ | ✓ | | | ✓ | | |
| 2.- To respect the other | | ✓ | | ✓ | | ✓ | | ✓ | ✓ | ✓ |
| 3.- To think of the other/put yourself in the place of the other | | ✓ | | | ✓ | | ✓ | ✓ | ✓ | ✓ |
| 4.- To develop environmental awareness | | | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| 5.- To be a ethical person | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | |

how effects on Nature, in turn, impact other people's lives (Clark *et al*. 2020). In this sense, integrating sustainability into chemistry teaching brings about a consideration of 'the Other'.

> **T8:** *So, it is also [in addition to promoting scientific skills] to promote a kind of super critical thinking […] It is like to be able to infer; like to say: 'if I am doing this [x action], [consequences are] going to happen'. I think [students] can develop basic scientific skills e.g. to analyse, formulate conclusions, by integrating sustainability into chemistry teaching. But an additional skill is to be able to think critically. It is to be aware of common wellness,* not just your own.

This view is related to the interconnection between the wellness of people and that of the environment ('It is to be aware of common wellness, not just your own'). This aspect is not only about supporting learners in recognising a reciprocal influence view (in which the wellness of people and that of the environment are connected); it also shows the integration of sustainability into education as including a cognitive structure that students should apply to search, change, and adapt to their environments. Hence, in the context of ESD, critical thinking skills help students realise that they live in a community and that their actions can affect not only their lives but all other living beings and Nature itself (Wals and Benavot 2017).

Eight teachers recognised that educating for sustainability is also about educating 'more ethical' people. This perspective is an essential aspect of ESD since, according to teachers, it supports learners in developing the necessary attitudes for being aware of – and responsible for – what happens around them:

> **T2:** I think [teaching chemistry for sustainability] should focus on skills important for society… it is not only to focus on personal skills, as the curriculum promotes. [Teaching chemistry for sustainability] is about promoting collective skills such as to think about the other, to see the other, to support each other.

> **T5:** So, [chemistry education for sustainability] supports students in knowing all actions have consequences… so, for example, I don't know – imagine a boy who wants to be an engineer and just because he wants to earn money, he performs a highly polluting process and simply disposes of the waste wherever. So, ultimately, [chemistry education for sustainability] helps them to be more ethical.

Such attitudes help students to be 'more ethical' and 'more human'. Such skills are 'collective skills' and aim students being 'more ethical'- 'more human' (e.g. 'to think in the other, to see the other, to support each other'; 'realise that what is around them is important'). This perspective confirms a sociological perspective for understanding the impacts of sustainability actions since human activities' impacts are strongly related to benefits and damage it can produce in the environment and society.

In summary, teachers believed integrating sustainability into chemistry teaching could allow them to support students in improving the skills necessary for them to live in the community. By integrating sustainability into chemistry education, students can work on attitudes such as thinking of the other, being tolerant, and respecting the other. According to teachers, it can also help learners to improve their critical thinking skills, specifically from a moral perspective. They go on to consider how their actions can affect their lives and the lives of those around them.

## Discussion

### *Teachers' understandings about sustainability in terms of the 3 pillars model*

Teachers' ideas on sustainability can be associated with 'Stewardship of Natural resources', as well as 'Thinking about and Affecting the Future' perspectives (Wheeler 2000, p. 3). The former is associated with responsible care of the environment, promoting responsibility for the environment. The latter links sustainability to current human decisions and their impact on the quality of life of future generations, interpreting sustainability as the capacity to think long-term.

It attempts to empower people to positively impact future conditions for human development (Wheeler 2000; Boström 2012).

Teachers' views regarding sustainability are closely related to the Brundtland Commission Report regarding meeting the needs of current generations without affecting the opportunities of future ones. It means interpreting sustainability as an inter- and intra-generational relationship of equity (Boström 2012; Burmeister, Schmidt-Jacob, and Eilks 2013). It involves evaluating human actions based on their impact on others' lives.

Teachers confirmed the need of supporting students in developing critical thinking skills from a moral and 'caring thinking' perspective. Supporting students in being aware of the effects of their actions on Nature and other living beings helps them to leave behind such an individualist perspective of thinking, which is associated with the Neoliberal model of development (Johnson and Morris 2010; Kopnina 2015). Teachers' ideas regarding integrating sustainability into chemistry education are associated with what they perceive to be their responsibility as teachers: to support learners in developing the skills and attitudes necessary for living in society. According to teachers, promoting critical thinking skills through ESD is rooted in helping learners recognise that their personal decisions must be constructed based on their impact on Nature and 'the Other' (Blades 2006). As Zeidler and Keefer (2003) confirm, science teachers ought to see themselves as moral agents and to recognise the moral dimension of teaching.

Considering teachers' views on sustainability, I interpret them as mainly (but not exclusively) linked to the environmental pillar of the three pillars model. Nevertheless, their understanding of sustainability brings out some aspects of the social pillar for sustainability (Magis and Shinn 2009) since teachers linked sustainability to human wellbeing. Using resources appropriately, avoiding pollution, and/or taking responsible care of the environment are positively related to improving people's quality of life. Hence, teachers' ideas surrounding the social pillar for sustainability are rooted in an environmental view since they associated social aspects of sustainability with the efficient management of (natural and or man-made) resources and the responsible care of Nature. Teachers in this study recognised the importance of supporting students in developing environmental awareness in order to achieve social plans for sustainability (Hopkins & McKeown, 2002).

In relation to the economic pillar of sustainability, no teacher spoke about how measures for protecting the environment could have an economic impact or about political or economic actions that can affect environmental preservation or degradation (e.g. supporting environmentally harmful activities) (OECD. 2001). Although teachers in this study associated sustainability with the effective use and management of resources, they related such actions only to personal decisions. They did not question whether sustainability and economic growth were compatible. Such questioning is crucial (Neumayer, 2003), particularly considering the current environmental and social crisis. In order to address current sustainability issues, it is fundamental to conceive of actions and responsibility from a societal perspective, considering personal and macro actions (e.g. industrial or other economic activities) occurring within societies.

Hence, actions for reusing, reducing and/or recycling waste have to be 'sustainable' activities associated with human actions happening at both personal and collective levels. Examples include activities linked to the exploitation of natural resources at an industrial level, or the effective management of resources at both societal and personal levels.

### *Teachers' understandings about sustainability in terms of ESD competencies: approaching personal and collective perspectives*

Teachers' views regarding chemistry education for sustainability are closely related to supporting learners in developing long-term goals and ESD competencies (Herranen, Yavuzkaya, and Sjöström 2021). Specifically, it means working on skills, knowledge and attitudes that are paramount to their lives in society (Reid *et al*. 2021). It is to promote an intrinsic view of ESD, which focuses on supporting students to think critically and make decisions in complex and unknown

situations (Herranen *et al*. 2020). I recognise in teachers' ideas the importance of education in encouraging students to think and act for sustainability (Hofman-Bergholm 2018). It attempts to educate citizens responsible for their actions (Sjöström and Eilks 2018) and can contribute to society's sustainable development (Tilbury 1995).

Nevertheless, teachers should also consider a societal perspective when describing implementing actions for sustainability (Ferreira 2019). Their ideas regarding implementing sustainability actions were centred around personal behaviour (see Figure 3). They mentioned supporting students in acting for sustainability by, for instance, reducing the waste produced in their daily lives or reusing/recycling things at home.

Although teachers recognised that the consequences of actions for sustainability affect humanity and Nature (Clark *et al*. 2020), they narrowed the practice down to the individual domain. If sustainability issues affect all living beings, as teachers asserted, it is necessary to consider a multidimensional approach to this concept, which includes human activities at both personal and other levels of society (e.g. industrial issues associated with sustainability) (Ferreira 2019). It is necessary to comprehend the complicated social and cultural connections between Nature and humanity (Clark *et al*. 2020).

According to Sjöström, Eilks, and Zuin (2016), focusing only on this individual and personal level for reflecting on human impact on the environment is closely related to a neoliberal development ideology. It promotes uncritical ecological citizenship since ecological awareness is reduced to the private domain where lay people are expected to voluntarily act responsibly, while macro actions and processes (e.g. industrial activity) continue to occur as usual (Sjöström, Eilks, and Zuin 2016).

The neoliberal discourse of activation and engagement confirms that individual citizens and their households are the contexts in which societal transformation for sustainability can and should happen (Blühdorn 2016). Citizens' actions are reduced to individualistic perspectives and the self-interest of consumers (Blühdorn 2016; Spannring 2019), for example, by managing our ecological footprint. Then, since achieving sustainability involves a reduction in the utilisation of energy and materials, sustainability involves a decrease in personal consumption (Knights & O'Neill, 2016).

Nevertheless, adopting only a personal/individual perspective for understanding the implementation of actions for sustainability means there is no way of transforming our worldview or the economic and cultural practices that have led us to the current socio-environmental crisis (Spannring 2019). Neoliberal discourse claims that consumer citizens – rather than economic and political elites – are the centre of power for transformation towards sustainability. Every individual contributes their bit, and the sum of individualised consumer choices and small-scale behaviour transformations will deliver what neither the globalised economy nor the decapacitated state can achieve (Blühdorn 2016).

Ignoring the effects of macro actions in society regarding sustainability (e.g. industrial activities) is to ignore the holistic and systemic view of sustainability. Since sustainability issues affect all living beings, including humanity, embracing a societal responsibility for achieving sustainability is paramount. Therefore, to address current sustainability issues, it is fundamental to conceive of sustainability actions and responsibility from a societal perspective (Ferreira 2019), considering personal and macro actions (e.g. industrial or other economic activities) occurring within societies. Examples include activities linked to the exploitation of natural resources at an industrial level or the effective management of resources at both societal and personal levels.

Narrowing chemistry education for sustainability down to reflect only on the impact of personal actions seems problematic. Considering that ESD is a teaching and learning approach that supports the five types of learning necessary to promote sustainable human development and to supply quality education: (i) 'learning to know', (ii) 'learning to be', (iii) 'learning to live together', (iv) 'learning to do', and, (v) 'learning to transform oneself and society', it is paramount to reflect upon actions occurring across different levels of society.

Since ESD is about 'learning to transform oneself and society', it is crucial to empower people with the appropriate skills and knowledge to critically reflect on common issues that challenge

societies now and in the future (Rauch 2015). These actions are associated with personal, social and political decisions. Hence, while attempting to support learners in learning about sustainability, it is necessary to consider sustainability's economic, environmental and social aspects while simultaneously helping students learn how to collaborate in creating a more sustainable society (Wals and Benavot 2017; Reid *et al*. 2021).

It is vital to support students in exploring viable activities for sustainability in their daily life context and in questioning why other actions are not feasible in their social contexts. The latter could help them reflect on social and political aspects of sustainability and demand change at a social and political level within their society. For example, in the case of Chile, it could be by acknowledging other actions for sustainability than recycling and/or questioning why recycling facilities are not available in many cities in this country. It means to question an instrumental perspective for ESD, which 'tends to provide ready thought-out ideas and solutions on how individuals and societies should deal with sustainability issues' (Herranen *et al*. 2020).

## Conclusions

This paper explored how ten Chilean chemistry teachers conceptualise sustainability and its integration into chemistry teaching. Participants in this research stated that they were unsure as to the meaning of sustainability. When talking about this term, they focused mainly on the environmental aspect of sustainability and personal actions for addressing sustainability problems. Teachers recognised their lack of knowledge and experience in integrating sustainability into education, similar to that noted in other parts of the world (e.g. Burmeister, Schmidt-Jacob, and Eilks 2013; Birdsall 2014).

From the findings of this study, and considering it is urgent to support students to act for sustainability, it is paramount to include sustainability discussion in teacher training courses (as other authors suggest, e.g. Herranen *et al*. 2020). It is fundamental to allow teachers to explore different conceptualisations of sustainability and support them in constructing their meaning. Based on their conceptualisation, teachers can explore different pedagogies for integrating sustainability into chemistry teaching. By reflecting on the meanings of this concept, teachers could decide which understanding of this term makes sense for them in the context of their classroom realities. This reflection could pertain to linking their understanding of sustainability to environmental issues only, the three pillars model, or any other understanding of this concept. This reflection becomes paramount, especially since teachers from different disciplines can perceive SD differently (Borg *et al*. 2012). Hence, it is crucial to support teachers in mastering this concept and reflecting on how it might be possible to integrate it into their teaching.

Sustainability integration into teaching chemistry cannot only be related to students' individual decisions or actions. Instead, it should also consider macro activities occurring in their society. Through education, teachers can work on transforming feelings of powerlessness into the sensation that students can make a difference. ESD should consider implementing activities that develop our students into citizens responsible for their environmental conduct and actively engage in socially and politically shaping their community or city (Ferreira 2019).

## Note

1. *In Table 1, 'T' means 'Teacher'. Hereinafter, in tables and quotes 'T' will represent the word 'Teacher'.*

## Acknowledgments

The author would like to thank the teachers who took part in this study.

## Disclosure statement

No potential conflict of interest was reported by the author.

## Funding

This research forms part of a PhD research founded by Agencia Nacional de Investigación y Desarrollo (ANID-BECAS CHILE (Grant Nº557/2015))

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