CREATING PEDAGOGIES FOR SUSTAINABILITY IN CHILE THROUGH CHEMISTRY EDUCATION: BENEFITS AND CHALLENGES FROM TEACHERS' PERSPECTIVES

Chile is in the top ten countries with environmental issues in the world. In this country, there are 37 documented environmental conflicts and most of them are related to mining industries. The uncontrolled pollution produced by industrial processes affects not only the health and quality of the life of disadvantaged groups and poor people but also destroys the habitats of non-human species around. Many of these ecological issues can be related to chemistry. Hence, chemistry classrooms in Chile can be good arenas for teaching for sustainability. Education for sustainable development (ESD) in chemistry education can allow students to have the opportunity to critically discuss and reflect on sustainability issues in Chile and brainstorm viable actions for promoting sustainable life. Identifying a viable connection between sustainability and chemistry teaching is a challenge that requires critical reflection of classroom realities and teachers' practices. This research aims to find out how Chilean teachers of chemistry integrate sustainability into chemistry teaching, while also recognising the challenges and benefits for doing it in their own classrooms. Data include field notes and audio recording of both class observation and in-depth interviews with Chilean teachers of chemistry. From the analysis of these data, teachers and I will collaboratively create pedagogies for sustainability in chemistry classrooms. These pedagogical materials will allow contextualisation of chemistry knowledge and promotion of important skills such as critical thinking and decision-making. Data collected attempt to highlight teachers' voices, their experiences and beliefs about what is possible to do in connecting chemistry education and ESD in the context of a country with free market approach to development such as Chile.

Keywords: sustainability, chemistry education, decision-making.

SUSTAINABLE DEVELOPMENT AND ITS CHALLENGES

The of understanding Sustainable Development (SD) is "value-laden" (Fien and Tilbury, 2002, p. 3). Definitions for sustainability and SD are based on economic, political and social priorities and interests of nations (Fien and Tilbury, 2002) and promote the balanced relationship between three main pillars: environmental, economic and social (Wals, 2009). Nevertheless, the current dominant conceptualisation of SD has an anthropocentric perspective, which tends to overvalue the economic growth of nations over both social and environmental justice (Kopnina, 2012).

Current perspective on SD has been criticised, mainly because it conceptualises 'development' as an infinite economic growth of nations (Bewitt, 2008). However, natural resources and Nature's capacity are finite. Uninterrupted economic growth, that the global economy promotes, has caused critical ecological and social issues nowadays such as pollution of water and soil, climate change and extending the gap between poor and rich (Räthzel and Uzzell, 2009).

What should Education for Sustainable Development (ESD) be for?

Education for sustainable development is an approach for teaching that is rooted in sustainability and attempts to promote values and skills for living sustainably in students. More specifically, it promotes knowledge of different aspects of sustainability, such as poverty, health, democracy, environmental care, human rights (Wals, 2009). It also works to teach skills that are relevant for citizenship education such as argumentation, critical thinking and decision-making.

Some authors prefer to use the concept Education for Sustainability (EfS) rather than ESD because the later is related directly to economic growth (because of the understanding of SD), and also has an excessive instrumental orientation, thereby missing personal, cultural and value dimensions (Stevenson, 2014). ESD tends to be an indoctrination of values and skills from dominant agendas of SD, which thereby teaches and encourages views of corporate and political elites and neo-liberalist ways of consumption.

Promoting ESD as a tool to change people's attitudes and behaviour in a pre-determined direction avoids autonomous thinking, the creation of instances for reflective discussions about educational outcomes and the exploration of more contextual ways to address issues of social and environmental justice. Sustainability education should have a transformative perspective that promotes a reflexive and critical analysis of the human role in the world (Sherman, 2009; quoted in Tippins *et al*., 2015) to address and challenge current unsustainable development.

The chemical industry and chemistry are fundamental for economic development of industrial countries, hence, have core roles in the sustainable development of modern societies (Rauch, 2015). Chemistry education can equip students to better understand and be involved in the democratic process of decision-making in society (Sjöström, *et al.*, 2015). Chemistry education for sustainability can allow students to understand deeply how the social, economic and environmental systems are connected with a sustainable word and also, to evaluate and think critically about these connections (Sjöstrom *et al.*, 2015).

This research aims to explore how Chilean teachers can teach chemistry for sustainability in their classroom realities. Chile has adopted a neo-liberalist model for development and various ecological problems (Temper *et al.*, 2015), which has led to social and environmental injustice and overvalues economic growth for development. Many of these ecological issues can be related to chemistry, which makes the chemistry classroom a potentially good arena for integrating sustainability into education.

The present study explores the following research question:

- How does a chemistry teacher integrate sustainability in her teaching?

- What are the challenges the teacher identify when integrating sustainability in her practice?

METHODS

This research is rooted in a qualitative methodology and has three main stages. First, sustainability/SD through chemistry education will be conceptualised. Secondly, the creation of pedagogies for chemistry for sustainability will be contextualised in the reality of each classroom. The third stage aims to evaluate and reflect on the application of the pedagogies created. Table 1 summarises the research plan for the study:

Table 1. Research Plan

	Research methods	Objectives	Participants
STAGE 1	Semi- structured Interviews	-To explore how teachers conceptualise sustainability - To construct a meaning for sustainability based on reflections and discussions - To explore how sustainability can be related to chemistry teaching	6 teachers of Chemistry
STAGE 2	Semi- structured Interviews	- To identify challenges for teaching chemistry in participants' classrooms	2 teachers from Stage 1
	Class observations	- To explore teachers' experiences in their own classroom	
	Semi-structured interviews	- To explore and discuss which aspects and pedagogical approaches can be used for creating pedagogy for chemistry for sustainability based on data collected previously, teachers' perspectives and researcher suggestions	
	Class observations	- To explore challenges for using the created pedagogy - To identify differences between intended and actual lesson plans	

S T A G E 3	Semi-structured interviews	- To discuss challenges and benefits of newly-designed pedagogy - To identify teachers' reflections and share ideas about the applicability of the created pedagogy -To identify possible changes in pedagogy	2 Teachers from stage 2

Participants are Chilean teachers of chemistry and will have an active role in the analysis of data. After interviews and class observations, data collected will be categorised using open coding. I will present analysed data to participants orally by summary charts or others. All decisions about what to review, change and analyse in this research are taken collectively. My views as researcher are not more important than teachers' perspectives. Teachers and I will work collaboratively to explore the best understanding of SD and ESD according to teacher's pedagogical experiences, their beliefs and the realities of their classrooms. These conceptualisations will be foundation for creating pedagogies for teaching chemistry for sustainability in this study.

RESULTS

Initial pilot findings reveal that there are potential benefits and challenges for these pedagogies. Firstly, it allows contextualisation of chemistry knowledge as it attempts to connect it through sustainability issues to every day life contexts. Secondly, pedagogies aim to promote important skills such as critical thinking and decision-making that are fundamental for citizen education. Thirdly, although collected data will be unique for the educational contexts analysed, it will be possible for other teachers to apply pedagogies created, adapting and changing some aspects according to their own classroom features. Finally, the data are valuable because they reveal teachers' pedagogical experiences and their beliefs about what is possible when connecting chemistry education with sustainability in the context of a country with a neoliberal approach to development, such as Chile.

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