

Chapter 10

Teaching Science in Chilean Environmentally Degraded Areas: An Analysis from a Critical and Ecofeminist Perspective



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10.1 Introduction: Socio-Environmental Conflicts and Science Education

The current *planetary emergency* that we are in (IPCC, 2018) has its origin in the socioeconomic system, specifically in the accumulation of capital and the search for short term particular benefits, carried out under the premise of a continued growth that is non-sustainable (Foster & Clark, 2012). In addition, demographic explosion, migration towards urban areas and *hyperconsumerism* of the more developed societies, continues to grow as if the capacities of the Earth were infinite (Vilches & Gil Pérez, 2007). This has generated unsustainable imbalances, which translate into pollution, destruction of resources, loss of biodiversity and cultural diversity, hyperurbanization and desertification. This, in addition to making our planet more inhabitable, increases inequality, extreme poverty, conflict and violence (Bence & Carter, 2011).

For South America, the neoliberal system has perpetuated the role of the *producer of raw materials*, such as mineral deposits, gas, oil, agricultural, forestry and fishing resources, initiated in our continent with the arrival of Christopher Columbus (Lander, 2014). South America has mainly become a supplier of primary resources to attend to the demands of the capital, through the logic of neo-extractivism (Machado, 2012). This consolidates a development model based on the over-exploitation of natural resources, most of them non-renewable, as well as on the expansion of production towards new areas, generating a breakdown of the regional economies, and the displacement of rural, farmer and Indigenous communities (Merchand, 2016).

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With the excuse of economic growth, the accelerated process of appropriation of natural resources has caused environmental deterioration in South America, which translates in forest loss, deterioration of natural habitats, endangered species and exaggerated use of fertilizers (Acosta & Machado, 2012). These environmental and ecological degradations not only affect nature but the whole social structure, modifying the lifestyle and everyday practices of the inhabitants of degraded areas, the communities in rural areas being the most affected. This has resulted in an explosion of socio-environmental conflicts related to access and control of natural resources that involve Indigenous and farmer movements, as well as mobilization and citizen participation, which is strongly repressed and criminalized (Svampa, 2012).

Many of these movements have women as protagonists. From this perspective, the practices of resistance towards neo-extractivism agree with certain principles that – not being exclusive of this view – can be grouped under the term *ecofeminist* (Svampa, 2015). Among them we can highlight acknowledgement of interdependence and ecodpendence (Escribano, 2017), overcoming of anthropocentric visions by placing the sustainability of life at the center (Pérez Orozco, 2014), creation of an ecological equality culture and the value of relationships and collaborative work for survival (Bernardos et al., 2020). In this way, feminism has earned prominence during recent decades. In Chile, the movement called *Women of Sacrifice Zones in Resistance of Quintero – Puchuncaví*, born in 2016, is a clear example of resistance, by which women that inhabit highly degraded areas –about which the government claimed that they need to “sacrifice”– seek to protect the life, health and environment of their communities through organizational, educational and judicializing practices (Bolados & Sánchez, 2017).

Within the context of environmentally degraded territories, science education has a particularly relevant role in the education of youth, especially when addressed from a place-based perspective. It would contribute to develop territorial awareness and critical thinking (CT), as well as competences for citizen participation. In addition, some ecofeminist principles can be a contribution to science education. Feminist scholars warned about the risk of teaching in isolation from real world, with knowledge that cannot be located (Haraway, 1991). Therefore, a perspective of science education that is territorial, critical and that is addressed on the basis of ecofeminist principles becomes relevant, especially in degraded socio-environmental contexts.

However, just as socio-environmental conflicts have divided society, so has the school-business dependence. Whether it be because of the schools’ desire to obtain job placements for their most socially vulnerable students, or because businesses involved are important job markets for parents, a subordination scenario is created. In it, not all school members dare to take a critical stance, which hinders the action of teachers. In this context, a teacher seeking to educate from a socio-critical perspective will be forced to challenge current political values and educational objectives – oriented towards nature exploitation, economy and consumerism – shifting to objectives aligned with sustainable development (Edwards, 2016).

In this chapter, we analyze, from a critical and ecofeminist standpoint, through the analysis of interviews and written records, the experience of two teachers and of a group of science teachers taking part in an in-service teacher education program. In all three cases, teachers work in the Aconcagua Valley – central area of Chile – in environmental degraded territories.

10.2 Socio-Environmental Context and Theoretical Perspectives

10.2.1 *Socio-Environmental Degradations in the Aconcagua Valley*

According to the Chile Map of Socio-environmental Conflict (INDH, 2020), the Aconcagua Valley is affected by nine socio-environmental conflicts, many of them also mentioned in the Global Atlas of Environmental Justice (EJAtlas, 2020). Located in the Region of Valparaiso (Chile), the valley is crossed by the Aconcagua River, which rises in the Andes Mountains and runs into the Pacific Ocean. At one end of the Valley, towards the mountains, we find the provinces of San Felipe and Los Andes. In this area, the great mining industry directly affects the watercourses, either due to contamination by spilling, or by glacier destruction (INDH, 2020). There is a great amount of water –2.000 liters per second– used in the mineral extraction process (OLCA, 2015).

On the same valley, towards the coast, are situated the cities of Quintero and Puchuncaví. This territory has been systematically impacted since the 1960s due to the setting of an industrial park that gathers various companies related to the smelting and refining of copper, five thermoelectric centrals, a port and gas maritime terminal, fuel, asphalt, cement, among other chemicals (Liberona & Ramírez, 2019). This resulted in strong atmospheric pollution, which has caused severe episodes of mass intoxication, leading to the temporary closing of La Greda School in Puchuncaví (INDH, 2020). It also caused water pollution, both of runoff and groundwater, affecting consumption of well water in rural areas, and seawater pollution, due to spilling and beaching of oil and charcoal (Saravia et al., 2016). Due to the loss of marine biodiversity caused by pollution, small-scale fishermen in the Puchuncaví-Quintero bay could not continue their jobs. All these reasons led to name this territory as a *Sacrifice Zone*.

In addition, the General Direction of Waters, has decreed all continental Provinces of the region as zones of water scarcity. Rainfall has decreased throughout the Aconcagua Valley (OLCA, 2015). Therefore, the water problem, its scarcity and pollution, represents an environmental degradation across this territory. MODATIMA (2014) frames this issue within the denominated “Water conflict” originated in the neoliberal economic model, through the Constitution and the Water Code of Chile (Ministerio de Justicia, 1981), implemented under Pinochet’s

dictatorship, that grants the administration and use of this common resource to private companies. Since then, mining, industrial and agro-industrial activities have aggravated the situation, generating socioenvironmental degradations in and around the territories where they take place.

From a social dimension, this has had direct impact on small-scale activities related to farming, agriculture and fishing for family subsistence. Because of the deterioration of both nature and quality of life, socio-environmental movements and ecological organizations have emerged, with the purpose of defending territory and waters. These groups have taken on the task of disputing power spaces through the generation of collaboration networks within the valley.

10.2.2 Critical Thinking and Critical Scientific Literacy in the Context of Environmentally Degraded Areas

In a context of environmental degradation, it may be expected a politically engaged science education, emphasizing transdisciplinarity, promotion of values and an orientation towards action. These actions aims are caring for ourselves and our surroundings, in a way that makes it possible for us and the planet to survive (Sadler, 2011; Bencze, 2017). In this way, we propose that science education should develop a critical perspective in which an activist disposition is promoted, with the purpose of increasing social and environmental justice, a vision termed *critical scientific literacy* (Sjöström & Eilks, 2018).

Critical scientific literacy involves the promotion of critical thinking, understood as the competence of developing independent opinions and the ability to reflect about the world that surrounds us and our participation in it (Jiménez-Aleixandre & Puig, this book). This vision of CT combines components of argumentation – such as evaluating knowledge from evidence and having the disposition to look for reasons and question authority– with components of social emancipation and citizenship – such as being able to develop an independent opinion, and critically analyzing the discourses that justify the inequalities and power relationships – (Jiménez-Aleixandre & Puig, this book). This perspective of critical scientific literacy and promotion of CT requires science teachers to be critical and transformative. This means viewing science as a product of social, cultural and political contexts, and understanding the school as a space for the development of ideas and generation of contextualized school knowledge, as well as their own role as agents of transformation (Moura & Silva, 2018).

In the context of degraded territorial contexts, being a critical and transformative teacher involves a high commitment to the territory, for instance the identification of local socioenvironmental problems as scenarios for contextualized science education that transforms the community. In rural contexts, students can take advantage of their local knowledge to make sense of school knowledge, but also what students learn in school influences, improves and increases the available knowledge in the

community (Roth, 2010). A curriculum that is alive, situated, addressing local socio-environmental problems, helps students to get involved with their own development and visualizes the utility of what they are learning for their territory. It also allows them to evidence the impact that science can have in our lives, and generate the need for ecojustice (Roth, 2010).

10.2.3 Ecofeminist Principles and Transformation from the School

From the dialogues between deep ecology and feminism, *Ecofeminism* allows us to reflect on domination, exploitation and appropriation of nature, interpreting human relationships and the subjection of women with this perspective. This is part of the foundation of the capitalist and patriarchal system (Federici, 2018) which invisibilizes the tasks associated to reproduction and care, such as children's care, supply for basic needs, health promotion, emotional support, or social participation. Therefore, we deem adequate to adopt the perspectives of critical Ecofeminism (Puleo, 2016) and Ecofeminism of the South (Svampa, 2015) to question the current development model, which affects environmentally degraded territories. It results appropriate then, to consider these ecofeminist principles, as a contribution to building processes of socio-environmental transformation from the school:

Acknowledgement of interdependence between people, and with nature (ecodependence) (Escribano, 2017): it opens the possibility to question social relationships and its forms of reproduction in school. It invites us to understand human interdependence and the generation of relationships for survival and mutual support.

Overcoming the anthropocentric vision and placing life sustainability at the center: The principles of feminist economy (Pérez Orozco, 2014) incorporate an integration of the production-reproduction tasks from the ethics of care, along to judging valuable all kinds of knowledge (Korol, 2016).

Creation of a new world vision anchored in the ecologic culture of equity, in the face of current social injustice scenarios that result in the violation of human rights and the destruction of nature (Escribano, 2017).

Highlight the importance of relationships for survival and wellbeing, to address objectives in a collaborative manner and overcome individualism (Bernardos et al., 2020).

10.3 Experiences of Chilean Science Teachers in Environmental Degraded Areas: From In-Service Teacher Education to Citizen Education

The three experiences that we analyze take place in the Aconcagua Valley, in the region of Valparaíso. We have been working for several years with schoolteachers, specifically from public schools that serve the more vulnerable areas of the population. Many of them live in environmental degraded areas, where many people do not have running water at home, and if they do, it is contaminated. Case 1 refers to

teachers from Los Andes province, the mountain area of the valley, that were part of a continued education program that promotes inquiry oriented towards the use of territory as scenario for critical scientific literacy. Case 2 focuses on a teacher from the same area, suffering a mega-draught, aggravated by the settling of monocultures and mining activity. Case 3 refers to a teacher from Puchuncaví, a coastal area of the valley, severely impacted by industrial pollution. From a territorial, critical and ecofeminist perspective, we address these three experiences, and ask these questions:

1. How do teachers relate to their territory and how is this relationship identified in the accounts of their educational practices?
2. What sense do they give to their practices and how do their accounts substantiate the promotion of critical thinking aspects in their students?
3. Which principles of ecofeminism can be identified in teachers and their narratives of their educational practices?
4. What are the difficulties of teaching science in an environmentally degraded territory?

In order to answer them, we analyze individual and group written records and teachers' interviews. The names are pseudonyms.

10.3.1 Case 1: Understanding Together the Sense of Educating in Sciences Through the Relationship Between Science Education and Territory

Since 2015, the Chilean Ministry of Education promotes ICEC (Scientific Inquiry for Science Education), an In-Service Teacher Education Program for the public system. It seeks the professional development of science teachers through collaborative work promoting the generation of learning communities. In our region, the Pontificia Universidad Católica de Valparaíso is one of two in charge of the program. Throughout these 5 years, we have sought to integrate the territorial component and the use of socio-scientific issues, encouraging participants to identify problems of their territory and use them for their teaching. Within this context we focus on three sessions (4 h each), in which 29 teachers of the Aconcagua Valley were invited to reflect on problems of their community and think together about possible ways to address them in teaching. For the purposes of this analysis, we examine individual and group written records. We highlight the use of narratives about their professional practice, the collaborative reflection regarding teaching practices that generates learning and the use of socio-scientific issues and planning tools, for the design of teaching sequences with a territorial focus.

10.3.1.1 How Is Science Teaching Understood in a Professional Education Community?

Activity 1: In 7 groups of 4–5 participants, teachers discussed about the sense of science education, around the questions: (a) What is for me the purpose of science education? (b) How can knowing science help my students in their everyday lives? (c) How can I link science teaching with the context of my students? and (d) How can I link science with current social events¹?

About the purpose of science education and the role of science knowledge in students' lives, teachers consider that they include: (a) Generating in students an understanding of themselves and their environment, helping them acknowledge that science is present in their everyday lives. (2) Training students to develop the abilities of discovery, research and reflection, promoting curiosity and bringing them closer to the world of science (3) Promoting CT and the ability to apply what has been learned in order to solve problems of everyday life and (4) Promoting environment care. Teacher 4 in Group 2 offers an example:

[knowing science] Helps them to be citizens that understand their environment, the processes and events that affect their everyday life, it helps them to make better decisions, to develop abilities they can apply in other fields, and also to understand how their actions have an impact on the planet.

Regarding the link between science education and the students' environment, considering the social crisis in our country, teachers mention that: (1) Teaching must be based on students' knowledge, considering their interests and experiences and use their contexts as a setting, carrying out activities that relate what they learned with their life. (2) Teaching must be oriented towards students learning to take care of themselves (e.g., nutrition), and of the environment, promoting awareness in the good use of natural resources (as water). (3) Reflection must be promoted among students, as well as social awareness, CT and better knowledge of national issues, so they can become agents of change in their communities. When talking about the national situation, teachers refer to specific topics, such as the water crisis, the quality of the health system and the pollution of the environment.

Group 6 concludes: “[as teachers we must] *Achieve significant learning, considering the context of each student so we can educate agents of change that are responsible for their environment*”.

In addition, Teacher 2 of Group 3 proposes: “*That students achieve their own critical thinking about issues and base it on information they manage in order to defend their ideals*”.

¹On October 18, 2019, a strong social outbreak began in Chile, an expression of great citizen discontent triggered by a high level of inequity and abuse. This outbreak was characterized by massive demonstrations and riots, as well as great police repression that led to the loss of human lives and massive eye losses. This situation led to the suspension of on-site classes in Schools and a reformulation of the teaching role.

10.3.1.2 What Is the Focus of the Groups' Lesson Plans? Views for a Teaching Sequence on "Water"

During the second session, teachers analyzed, in groups, the problem "What do I make for dinner?" The activity allowed teachers to relate an everyday decision to aspects of science learning, such as pyramids of energy and biomass, the salmon culture in Chile and socio-environmental significant crises such as the red tide and its relation to tons of salmon thrown to sea in the Island of Chiloé. Then, they constructed collective definitions for critical scientific literacy and used an analysis tool in order to generate classroom proposals, considering their reflections. After working in groups they presented their results in a plenary session.

Activity 2: Use of an analysis tool of the content to be taught for the creation of learning proposals with a focus on critical scientific literacy.

In order to describe teacher proposals, we examine the answers of three groups that proposed similar topics related to water. The analysis tool of the content to be taught was a schema that includes 6 elements related to critical scientific literacy (CSL) and pedagogical content knowledge (PCK). It required teachers to discuss around: (1) Selected concept, (2) Key idea, (3) Relation with social, political and economic aspects, (4) Learning difficulties and student's interests, (5) Teaching strategies and resources and (6) Possible actions and strategies for evaluation. A summary of the results of the three groups is presented in Table 10.1:

10.3.1.3 Teachers Report Their Own Learning

At the end of the third session 26 (of 29) teachers answered a "ticket out" that include the following questions: *What did I learn today?* and *How does my learning modify my classroom practice?*. Figure 10.1 summarizes the analysis of the categories in their answers: Curriculum, Teacher, Context and Student, with the references to each. How teachers view: (a) themselves: they stress the importance of fostering a *critical scientific literacy focus* and they state the importance of analysis tools such as the one used for the analysis of content, to intentionally use activities promoting students' critical and scientific literacy; (b) the pedagogical context: they refer to a vision of science teaching centered in the relations of their students to the *political, cultural and social world*; in their narrative they refer to socio-scientific issues as vehicles that allow their students to develop scientific thinking to be able to respond in the aforementioned scenarios; (c) their students: considered as *decision-making* subjects; teachers should consider *students' interests* and *daily life situations* to support a student-centered science learning; (d) the curriculum: they account for two dimensions, the concept of "*key idea*", however, when highlighting their own learning, they only mention the concepts or "*keywords*" learned during the session.

Table 10.1 Teacher analysis of the content “Water”

Selected concept	Teachers propose that the concept to be taught be simply <i>water</i> , or the problem associated to it (<i>draught</i>)
Key idea	Proposed in three ways as a: concept: “ <i>Care of the Environment</i> ”; brief scientific idea: “ <i>Water is a fundamental element for life</i> ”; socio-environmental problem: “ <i>We are running out of water, therefore, it is necessary to take care of its use and do so in a responsible manner, recycle and preserve the available water sources</i> ”.
Relation with social, political and economic aspects	Learning about water should involve an understanding of the context: “ <i>It is necessary to become aware of inequalities regarding access to water</i> ”, as well as to understand that “ <i>there are no policies that regulate the use of water in our territories</i> ”. Teachers point out that it is important to consider real situations, such as “ <i>the use of large amounts of water for mining, to the detriment of other essential uses</i> ” or “ <i>Animal feed shortage</i> ”. It is also important to develop attitudes, such as awareness and collaborative work that lead students to take a position on environmental problems and promote water care actions for the local community.
Learning difficulties and student’s interests	References to three dimensions: (a) Students' previous ideas that hinder learning: “ <i>Water is an inexhaustible resource</i> ” or “ <i>students do not place freshwater or seawater within the water cycle</i> ”. (b) Attitudes: lack of awareness or interest from the students and their families (c) Pedagogical context or local territory: little availability of safe water in their territories, social reality and levels of water care.
Teaching strategies and resources	Mentions of experience – based learning, the use of concrete material (models), and inquiry projects, like the design and application of a survey to know about water use habits in the community or the comparison of images of the river at different years
Possible actions and strategies for evaluation	Proposal of a call to action to students, through communicating the results of their inquiring: “ <i>Presenting conclusions at the School</i> ” “ <i>Radio program and use of social networks</i> ”. Propose actions oriented towards citizen participation: “ <i>Creation of a water care brigade</i> ”, “ <i>Publicly denounce products that use more water for their production</i> ”, “ <i>Design posters about the good use of water at home</i> ”.

Teachers also mention in their responses that they would require more courses or tools to relate the curriculum with the formative goal of critical scientific literacy. We interpret this as declarative statements that would reach greater development when they elaborate proposals to address real territorial issues.

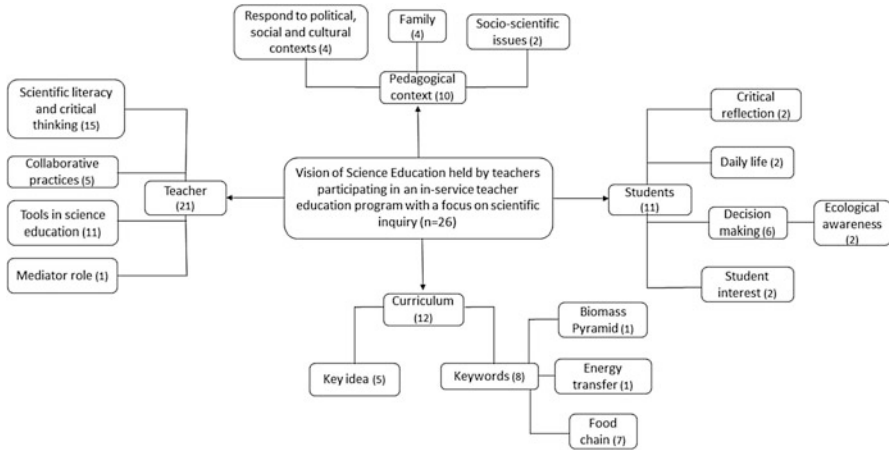


Fig. 10.1 Vision of Science Education held by teachers participating in an in-service teacher education program with a focus on scientific inquiry. (n) indicates the number of participants (N 26). The categories of the teachers' responses in their "ticket out" are displayed, indicating the presence of the subcategory in their writings

10.3.2 Case 2: To Include Students, the Experience of a Teacher in the City of Los Andes

The truth is that I could not find a more beautiful profession, where what you give comes back to you, as it happens in teaching [...] To do what I do, makes me very happy [...]. I feel that I don't work alone. If I have questions I can ask around, now I have a network of colleagues to go to... (Paula, teacher from Los Andes).

Paula is a high school biology teacher currently working in a school in the city of Los Andes; their students are between 13 and 18 years old. She lives with her 8-year old daughter and her 81-year old mother. She describes herself as *busquilla*,² since she finds different job opportunities such as selling clothes, making jewelry or nail art, whatever brings extra income to the family. Among her academic achievements, she has participated twice in the ICEC Program, in addition to an in-depth course on inquiry. Paula has carried out scientific inquiry projects with her students, achieving recognition at city and national levels. She is currently leading and coordinating the ICEC teacher science network in her city. She is a mother, daughter, sister, aunt, friend, teacher, homemaker, guide and partner. Throughout time she took on the role of supporting and guiding the teacher science community, showing a disposition to collaborative work focused on service and peer accompanying. She keeps a trusting relationship with her students, centered on dialogue and their interests. She describes herself as a caring and understanding teacher when it comes to the different interests of the kids, especially teenagers.

²In Chile, a person that is ingenious and persistent regarding the search for sources of income.

10.3.2.1 Highly Degraded Territory and Citizens' Response

Paula's description of her territory is based on comparison: she explicitly mentions marked differences between the space she now inhabits and the one of her childhood. The accounts of her grandmother, mother and her childhood memories describe an environmental deterioration of her territory "[...] *the river does not catch your attention as it did when I was a child, when you travel to San Esteban or San Felipe and go through the bridges, you can see only drops of water coming [...] before, the water flow was such that you could hear it from blocks away [...] there is a completely different vegetation, it doesn't rain like before, [...] the water has a strange smell, like that of a disinfectant [...]*". She refers to urban growth, the decrease of the water flow of the Aconcagua river, which crosses her city, and pollution, "[...] *the problem we have with the mining company, [is that] they have their "good neighbor" slogan but in fact they are not so good neighbors because they produce waste and always discharge their tailing to the river*". The exploitation of natural resources, such as water, directly affected by pollution and extraction, appears as the greatest impact in the Aconcagua river basin, where the draught takes its toll on the most defenseless ones, such as the small-scale farmers that cannot compete with big producers of the area, as avocado exportation. Water became an economic good when Chile turned into the only country in the world to privatize this public resource, under the concept of *Right to Water*. Paula tells the story of a relative that can pay for their right to water only once a week, for a couple of hours. "[...] *Suddenly we arrived at a canal and my cousin says: This is where these guys keep the water! The canal was almost overflowing, and my cousin receives a very small flow of water once a week. She and her husband work, and if the water arrives and they are not there, they lose it.*" In this context, the teacher has promoted, along with her friends and neighbors, different actions at home and neighborhood levels, such as the installation of filters to purify greywater. She also mentions how the members of the group have organized irrigation "[...] *we give each other information among neighbors [...] it is hard for me because I don't have a filter, but I still go and water the crops using cans, it is good exercise*". The community is organized around different activities, such as recycling and the maintenance of plastic collection containers, something she values and encourages.

Among the initiatives around the water problem, Paula mentions collaborative work carried out with teachers from schools in San Felipe and Los Andes, part of the ICEC Program. Together they designed projects specifically related to the Aconcagua river. "[...] *in fact, all teachers from this area had water-related research. [My colleague] wanted to investigate heavy metals found in the water in an area of the river and I was researching "how irrigation with river water affects plants". The river was important to us*". As a group, they started to review their research documentation, which allowed them to gain deeper knowledge into the water issue. This research led them to become a part of a city initiative in which they expressed their rejection to a mining project, which through the expansion of excavation works, endangered 18 rock glaciers and five white glaciers, which,

because of their closeness to the mining company sites, became a threat to them. This caused a generalized rejection from these local groups, and the mining company decided not to carry out the project. “[...] *we made a lot of noise with that; we moved a lot. [...] they closed the group [...] in fact the woman that led the group had to disappear for a while [...] we even held secret meetings*”. Paula’s participation, along with other teachers in her High School ended when the school principal forbade them from being a part of this investigation “[...] *at that time a colleague and I were very much committed to continue with the investigations, but our school principal at the time told me: be careful, do not mess with them [the mining company]*”. Considering this, Paula put her research project aside.

10.3.2.2 Classroom Practices in the Local Context and Development of Critical Thinking

In her teaching, Paula considers the narrative itself to be a process that creates meaning. She tells stories to her students, which somehow allows them to connect with the territory they inhabit, as a way to develop CT. “[...] *I try to integrate critical thinking as much as possible [...] I like to tell stories in my classes, Did you know that?... when I was a kid... my friend told me, etc... what I do is transport them to a comparison of what I am telling them and reality. [...] when the student feels close to something, not just something that is being told to them but that they live daily, they start to get involved in their learning*”. Paula states that she encourages scientific inquiry as a methodological approach in her teaching. “[...] *I love when they ask questions! It is difficult for them at the beginning*”. To get students involved with territorial environmental problems is a way to direct their interest towards inquiry, “[...] *I feel that when you teach you have to not only deliver content but also the tools so they can continue to develop [...] we have to be very realistic as teachers and bring the content to their reality and current situation [...] sometimes there is something that catches their attention and they discuss it in wonderful debates. [...] I don’t mind if I feel I am straying away from the content, I let them continue since I feel there is much gain in this*”. Inquiry can be developed from different approaches, however if it is linked to the territory learning would be more significant. Paula carries out research with her students, such as to establish relationships between the contamination of the Aconcagua river water that is used for irrigation and the growth of vegetables. The research lines developed in the classroom invite students to participate in different aspects of scientific research and the understanding of how scientific knowledge is generated, which is a crucial aspect for the development of critical scientific literacy. “[...] *Students in general are used to receive everything already done, and to be told what to do or what not to do. I like to bring about this in class and have them think and research. It is important that kids experience it*”.

10.3.3 Case 3: Critical Scientific Literacy Outside School

We have an industrial ring that started with a few thermoelectrical units and this has grown exponentially. Suddenly we have an industrial system with many companies and most of them pollute. This has impacted the whole ecosystem: air, earth and sea.

Collaborative work is fundamental in order to generate something that will impact the communities, something that is relevant. For this, each actor has to get involved in the action (Marisol, teacher from Puchuncaví).

Marisol is an elementary and special education teacher in the School Integration Program (PIE, for its name in Spanish) in a school located in the Las Ventanas community, in the city of Puchuncaví. She is also a singer in a traditional folk group from La Greda, enjoys Latin American music and playing the guitar. There, she says, she has connected with students: *“Being a teacher and a woman is a great challenge, especially in areas of high vulnerability. To connect with them is very important, to their lives. What this job entails is much deeper than providing knowledge and content, and implies values that go beyond this”*. The vulnerability of this territory, she tells us, is marked by environmental deterioration, which has directly affected the health of boys and girls, resulting in a high rate of students with learning difficulties associated to their neurodevelopment, along with respiratory problems, asthma and cancer. After these consequences were made evident, in addition to mass intoxication episodes which affected the La Greda school, among others, the population has achieved greater ecological awareness. This is directly related to the role of some social movements, comprised by teachers and other inhabitants, who have promoted CT through raising awareness about the socio-environmental conflict and the deterioration caused by industries located in the area. At the same time, she says that youth has had a great participation, joining this struggle in a significant way.

10.3.3.1 Building Collaborative Work in the Community

As a consequence of socio-environmental damage caused by the development of the industrial ring, in which most companies are highly contaminating, Marisol has made relevant social and political decisions, joining a group of residents of the Quintero – Puchuncaví bay, formed 15 years ago, called *“Communities for the Right to Life”*. According to her account, this group responds to a form of collective self-organization in the face of the contamination that during the 1990s *“had no filter”*. They began to work for the environmental literacy of the population, raising awareness about these problems: *“we would go to the communities, the small towns, neighborhood councils and we showed them videos so that people could be aware of what was happening to them”*. This task continued and encouraged the generation of socio-environmental movements; among them the *“Women of Sacrifice Zones in Resistance”* network has emerged strongly. This group of women has had a center stage role in the visibilization of the conflict and the violation of rights in this territory. Among their characteristics we can highlight the generation of support

networks through different organizations, Human Rights, International Courts, the support of scholars and experts in health issues, ecosystems, biology and chemistry, NGO's that, together with the population's environmental education and literacy, have led them to present the socio-environmental degradation happening in the territory to different media and at different scales.

10.3.3.2 Critical Scientific Literacy Outside of School in Highly Deteriorated Territories

For this Puchuncaví teacher, the integration of the pedagogical practice in the fight against pollution has been a difficult path to travel. First, because her school has a direct relationship with the polluting companies, through a system that facilitates the future entrance of students as workers of these industries: *“here we have our differences, it is difficult, so we have to leave it here, we cannot go further. But we can move forward through the different organizations outside the school”*. This is the first obstacle hindering implementation of critical scientific literacy initiatives within the School. Especially in territories that have been highly degraded and intervened by the industrial businesses, where their dynamics of introducing themselves within the communities, and compensating them, are characterized by material and financial incentives: *“That’s why is so hard [...]... here it is hard to fight against the powerful”*. From this perspective, education becomes a form of resistance of a political nature, and at the same time, action-oriented educational practices are faced with limitations. In spite of this, she states that outside school, students participate of rallies and protests around the city that end at the doors of the industries. These spaces enable to articulate and highlight the importance of different knowledge among the citizens, where they complement the artistic dimension through music, dance, theater interventions, with discussion groups – assemblies with fishermen and meetings with scientists, dialogues with communication media, among others.

10.3.3.3 Education of Critical Citizenship in Interdisciplinary Spaces

About critical citizenship, Marisol suggests that Citizenship Education can be one of the fields through which topics related to socio-environmental contamination and degradation could be addressed from a CT perspective in school, considering *“the importance of the role they can play in decision making when they elect their authorities and how these elections can affect the interests of the community”*.

She emphasizes the importance of integration of knowledge in collaborative and interdisciplinary spaces, through the participation of boys and girls in talks, *“Presentations by experts, doctors, environmentalists, human rights representatives”*, artistic events, rallies, demonstrations, workshops on environmental issues. These allow students to *“express their feelings on the environmental topic”*. On the other hand, she considers essential to strengthen student organization, and empower them

on this topic. Marisol states that collaborative work can generate changes that impact communities “*and for this every actor must get involved in the action*”. In this sense, it is possible to observe the socio-environmental problem through a space where each collaborator can contribute with their own abilities, generating together a work of value.

10.4 Discussion and Implications

Teaching science in a territory marked by socio-environmental degradation faces teachers with certain dilemmas, both inside the school, and in the development of their role as a political subject of the territory they reside in. Often, the promotion of actions motivated by critical scientific literacy is limited in schools that receive financial incentives from polluting companies, or in students that have families whose only income comes from them. This hinders the development of CT, which also involves students’ formation of independent opinions (Jiménez-Aleixandre & Puig, this book), given that censorship, sometimes explicit, exists in educational spaces. Overcoming these obstacles requires, firstly, to address socio-environmental problems from a socio-scientific perspective, that will allow its understanding as a contextualized problem, enhancing a territorial approach that is anchored in the local reality of each school. Secondly, the incorporation of ecofeminist perspectives to educational practices could support the promotion of attitudes, such as collaboration, equity, wellbeing and a harmonic relationship with nature, opening new paths for transformation (Rodríguez & Herrero, 2017).

10.4.1 Educational Practices Contextualized to the Territory

The teachers that collaborated with this study possess a high sense of territorial awareness, associated to a critical vision about the socio-environmental conflicts in their territories. This leads them to promote, in different ways, critical thinking and science teaching from a situated knowledge (Camacho-González, 2020). For the teachers participating in the in-service science teacher education program, we identify the need to know their students and the territory they inhabit in order to design contextualized learning opportunities, so they could apply what they have learned to everyday life. In the case of Paula, territory becomes a setting for the development of scientific practices, which goes hand in hand with educating citizens that are able to understand the world and make everyday decisions.

We can see that in the three cases strong ideas emerge related to critical scientific literacy and teaching for life within the local context. At the same time, participation in professional learning communities supports teacher practice on the use of new knowledge and the promotion of change in collaboration with others (Taotao Long et al., 2019). In this sense, the Inquiry program discussed in the first case creates

dynamic spaces that invite to (1) question one's own vision about science education (2) build a collective vision of science education (3) make science education territory-related, based on collaboration. These spaces seem to have great relevance for promoting socially active professional trajectories. The exchange of experiences and the construction of common visions allows for the development of didactic proposals that expand the initial visions of teachers.

10.4.2 Promotion of Critical Thinking Inside and Outside of the Classroom

The development of CT can be identified in different levels in their narratives. In the case of the teachers in the program, the importance of promoting CT in students is declared in a generic way. This is associated to reflection about the problems of the territory, both locally and nationally, in order to become agents of change. This agrees with the aspects pertaining to critical thinking proposed by Jiménez-Aleixandre & Puig (this book), in relation to developing the ability to reflect about the world surrounding us and our participation in it. In the accounts offered by Paula, development of CT is rather associated to the development of scientific abilities and assessment of knowledge from evidence, which the teacher promotes through inquiry projects that use the territory as the scenario and propose to evaluate the impact of environmental issues *in situ*.

For Marisol the purpose of her teaching practice is directly related to her conception as a political subject within the area she resides in. She takes out of the classroom proposals that promote the development of their own opinions through CT, among other performances (Jiménez-Aleixandre & Puig, this book). This includes networking with other community actors, scientists, experts and social leaders that strengthens students' own opinion, through access to knowledge including different points of view. This would support the development of a sense of children and youth as agents of transformation of their local reality (Moura & Silva, 2018), encouraging some eco-social values related to the consolidation of an organized critical citizenship (Rodríguez & Herrero, 2017).

According to Jiménez-Aleixandre & Puig (this book), the selection of the different socio-scientific topics that teachers consider appropriate to include in their teaching, would support the development of scientific argumentation. In the case of Paula from Los Andes, she selects, on one hand, the issues that emerge from the extraction and contamination of natural resources such as water, and on the other, she uses a methodology with a focus on scientific inquiry, which allows to obtain evidence for the questions proposed by students. According to the authors, one of the fundamental aspects of argumentation and critical thinking develops through the appropriation of scientific practices. The teacher fosters debates in her classes where students can choose between one position or another.

10.4.3 *Principles of Ecofeminism That Facilitate the Development of Critical Thinking*

As a concluding thought, we propose that it is relevant to take into account those principles of ecofeminism that would help in the development of a critical scientific literacy based on the analyzed cases. Our analysis points to the importance of collaborative spaces, understood as the foundation of the weave of life itself, both inside and outside the classroom. From an ecofeminist perspective, the recognition of the relationships for survival, makes it possible to replace an anthropocentric vision for another one that places life sustainability at the center (Pérez Orozco, 2014), valuing, above all, local knowledge, support networks and interdependence within the territory. In turn, the incorporation of multiple knowledges that facilitate the development of critical thinking (Jiménez-Aleixandre and Puig, this book), would allow to problematize the ways of life imposed by the development model (Korol, 2016), especially in territories affected by neo-extractivism (Machado, 2012; Merchand, 2016). This opens new reflection spaces around the ecological crisis, encouraging thinking about environmental justice. Therefore, as these principles are incorporated to the educational practices, it is possible to build new ways towards an ecological culture of equality (Escribano, 2017), for the creation of a transforming educational practice.

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