

Culturally Relevant Science Education and Critical Thinking in Indigenous People: Bridging the Gap Between Community and School Science

Alejandra García Franco, Lisber Farrera Reyes and Alma Adrianna Gómez Galindo

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A. García Franco

Universidad Autónoma Metropolitana – Cuajimalpa. México.

e-mail: agarcia@correo.cua.uam.mx

L. Ferrara Reyes

Escuela Telesecundaria 714 David Gemayel Ruíz Estudillo

Carretera municipal Yochib, Oxchuc, Chiapas, México

e-mail: junontoni01@outlook.com

* A.A. Gómez Galindo

Unidad Monterrey, Cinvestav. México

e-mail: agomez@cinvestav.mx

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Abstract Culturally relevant educational practices look to facilitate students' dialogue between their own ways of knowing and scientific ways of knowing. Such practices give space to focus more on real-world issues that consider students' lives, making science education a space with opportunities for identity development. Working with indigenous students makes us aware of the relevance of students' knowledge and how this could be considered in the development of critical thinking related to their knowledge and practices. From the perspective of critical pedagogy and a decolonial stance, we present some examples of work with students and teachers in the Maya Highlands, related to their community work in *milpa*, a polycrop based on maize (corn), squash and beans. The milpa, an agro-ecological system, is considered fundamental in the constitution of Mesoamerican societies, and is also a fundamental activity in indigenous communities in Latin America. By presenting this data we show students' special interest about using fertilizers and its environmental impact. Taking into account the efforts to integrate indigenous (traditional) knowledge into the school science curriculum, in this chapter we discuss the opportunities for an intercultural dialogical education that could open new paths to understand the complex relations between environmental education and critical thinking in specific contexts.

A secondary school in a community in the Mayan Highlands. Students speak Tseltal and their teachers speak Spanish. Students belong to farming families and practice *milpa* as a subsistence crop. In the community there are also coffee plantations and collectives of knitter women who sell their handcrafts in larger cities. Yochib is in one of the poorest towns in Mexico and subsistence depends mainly on agriculture. Yochib in Tseltal means 'sump' and this is literally what it is: a sump between two mountains where a river goes by.

What science is relevant for these 14 to 17 year old students in the second year of secondary school? How can they achieve critical thinking that is relevant for their lives?

1. Introduction

This chapter comes from the work we started several years ago when we approached indigenous communities in southeastern Mexico (Montaña de Guerrero) as part of a large research team documenting traditional knowledge about cultivation techniques (*milpa*).

The question back then was: what happens to this amount of knowledge in school? How is this knowledge considered? The conclusive answer was that traditional/local knowledge was completely out of sight in school and, even if teachers were indigenous or farmers, the only relevant knowledge was the one prescribed in the school curriculum. Ever since, we have worked intermittently with teachers and students in indigenous and non-indigenous communities. We are three authors in this chapter: first one is an educational researcher working in a large university in Mexico City; second one is a science teacher in Yochib, a small town in the Chiapas Highlands; third is an educational researcher in a public research institution in Monterrey in northern Mexico. We are not members of any indigenous group. Our basic preparation is in the natural sciences.

Our main concern comes from questioning which is the value of science education in rural schools, and particularly in indigenous communities. It is relevant to say that indigenous voices are rarely present in academia and as non indigenous researchers we are looking forward to constructing bridges between school science knowledge and indigenous/traditional knowledge. In the present chapter we discuss how traditional knowledge could be valuable to promote critical thinking in the classrooms and why.

We recognize that global phenomena such as climate change and migrations are part of the current crisis and recognizable for everyone. However, these problems have different dimensions in particular communities (Gruenewald and Smith 2007). For indigenous people global problems are accentuated because of the accelerated loss of indigenous languages and territories. For different reasons local knowledge that permits the recreation of life is being eroded (i.e. Maurer 1977).

These problems and particular conditions of different communities are fundamental to think about the role of science education, how it can contribute to citizen preparation and provide students with basic tools to understand the world they inhabit and transform it in a sustainable way (Valladares 2010). There is a global imperative to promote that knowledge, language and practices of indigenous people are respected and conserved. The relation between such knowledge and sustainability has been recognized in several studies (i.e. Oviedo, Maffi and Larsen 2000, Boege Schmidt 2008). In this sense, the school plays a relevant role. However according to Harmin, Barret and Hoessler (2016 p. 2) "In order to effectively and ethically engage with indigenous knowledge holders and

address the complexity of sustainability problems in the context of socio-ecological systems, academic institutions are tasked with decolonizing approaches to knowledge creation and addressing ongoing privileging of some knowledge forms over others”.

Our approach to science education comes from recognizing the need to establish dialogues between traditional/indigenous knowledge and school knowledge. In previous work we have explored the value of incorporating traditional knowledge in the science classroom, particularly indigenous knowledge about cultivating *milpa* in southeastern Mexico (Torres Frías, Gómez Galindo, García Franco and González Galli 2017, Gómez Galindo, García Franco, González Galli and Torres Frías 2019). *Milpa* is a polycrop (with maize, beans and squash as main components) that is fundamental to sustainability, food sovereignty and community organization.

We have strived to integrate knowledge about *milpa* in school in order to achieve that what is learnt is valuable to students’ lives, their autonomy, community values, identity and, ultimately to promote social justice, where school gives something valuable to everyone. Establishing these dialogues between traditional/local and scientific/school knowledge has allowed the visualization of students’ and teachers’ knowledge about different topics and how they could be related to school knowledge (Gómez Galindo and García Franco submitted). But it is clear that we need to expand our gaze to incorporate not only knowledge but also ways of thinking that sustain diverse ways of life.

In this chapter we problematize, from a decolonial perspective, what we understand as school science where critical thinking and biology teaching are situated in specific communities. We present a trajectory that allows the identification of relevant knowledge that can be approached from this critical stance. We recognize that there is a need to rethink what we understand as critical thinking and how we can promote it so that science education is not an artifice but rather that it provides tools to students and is relevant to their identity construction.

With this in mind, we present some questions that guide our narrative:

- What is the contribution of considering students’ traditional knowledge in our understanding of critical thinking in the biology classrooms?
- Which is this traditional/local knowledge that is potentially valuable to develop critical thinking?
- Which science/school knowledge can dialogue with traditional knowledge in ways that allow students to understand and transform their particularly lived world?

- How is identity negotiated when traditional knowledge is incorporated in the classroom?

The chapter is divided in three parts. In the first part we present theoretical elements that allow reflecting about the role of traditional knowledge in developing critical thinking in situated practices and how the frameworks of critical interculturality and decolonialism can be related to social justice. In the second part we introduce examples of secondary students' work that allow the concretization of the positions presented in the first part. In the third part we present some perspectives for this work, underscoring the collaboration established with teachers. We also offer some final reflections.

2. First Part. Culturally Relevant Science Education and Critical Thinking

To think about a transformative education that allows the student to construct meaning for school knowledge and use it to transform their circumstances we need to extend the idea of critical thinking and recognize that school learning and instruction are not neutral and transparent processes (McLaren 1997). To do so, we rely on the notion of critical pedagogy proposed by Henry Giroux y Paulo Freire.

Critical pedagogy construes education as a tool for *conscientization*¹, to recognize one's own place in the world and critically interrogate it. From this stance it is indispensable that students and teachers voices are considered because these voices are agents of change and critical observation of reality.

According to Giroux (1997, 2003), schools are sites for struggle and possibility where teachers and students can take the spaces that school situations offer to resist² the uniformity mandate. But this resistance is only possible if classroom knowledge makes sense to students, is relevant for their lives, and allows them to have a voice. According to Farrera (2018) this implies retrieving wisdom, stories and cultural practices. Curricular content and the way it is approached, as well as pedagogical practices should find resonance in students' vital experiences

But that is not enough, school should possibilities students' for a critical stance. In this sense, knowledge should promote emancipation (Freire 1970) and to do so it is necessary to consider concrete and real problems that students and teachers face

¹ Conscientization (concientización) is a concept proposed by Paulo Freire. It means 'critical awareness' or 'critical consciousness'

² This term is derived from resistance. It is widely used in postcolonial and decolonial studies to describe the political position of native/indigenous people facing colonialism.

everyday. There is no other way that knowledge allows us to interrogate reality. Students should be able to pose questions about topics that are important for them and that allow the recognition of their own and community knowledge (Carreño 2009/2010).

In a globalized world, Freire's position about critical pedagogy is still current. This is particularly true for students that are part of indigenous people who have seen their knowledge and language excluded from school. It is necessary to make students participate in the classroom generating authorship processes where students head toward production and not reception of knowledge (Subero and Esteban-Guitart 2020). Critical pedagogy signals the route to choose subjects and ways to work.

2.1. Intercultural Science Education from a Critical Perspective

Research in science education has revealed how science taught in schools is far from students' interests. Even if researchers and policy makers advocate for science education as necessary in the preparation of citizens that are able to make informed decisions and participate in the construction of a more just and equitable society, in practice this is seldom realized.

Sociocultural perspectives are every time more frequent in science education (see Milne, Tobin and DeGennaro 2015). Different critics to science education have shown its cultural, local and situated character and have modified the narrative of science as objective, neutral and universal knowledge (Carter 2004). Science is a practice inserted in power relations (Gorbach y López Beltrán 2008). Its coexistence with indigenous or local systems of knowledge has also been recognised. Moreover, the presence of students from different cultures and languages in the classrooms have made inevitable to question the different ways in which science and its normative culture are related with students that come from different cultures and talk different languages (i.e. Hutchinson 2014).

Countries in Latinamerica have a pluricultural composition. In Mexico this diversity has been recognized in the political Constitution since 1992. This recognition made the approach of interculturality indispensable in education. However, education for indigenous people has been considered as a way to 'bridge the gap', assuming one culture as dominant (Ramírez Castañeda 2006). Intercultural education in Mexico has pretended to annulate specific indigeneity resulting in a double discrimination. On one hand educational results in the sector are at the lowest level, and on the other hand, local knowledge is eroded through its folklorization (Ramírez Castañeda 2006).

Mexico is a megadiverse country and there are 64 different linguistic groups with more than 365 dialects, but there is a national curriculum that does not consider the diversity of geography, cultures, ways of thinking and recreation of life. Therefore, we need to think how school (formal education) can contribute to students' preparation and in the different tactics (according to De Certeau 1996) that teachers and students generate to subvert and resist the educational imperative of uniformity.

Interculturality can be considered as a result of indigenous people struggles and their demands for recognition. It can also be understood from globalisation and find it tied to power, capital and market. Walsh (2009) describes three perspectives for interculturality: relational, functional and critical. Relational interculturality recognizes the differences but does not question them, neither recognizes conflict. More dangerous is functional interculturality which intention is to include socially excluded groups to the current system. The 'others' are recognized only to be co-opted, turning education into a domination strategy whose final objective is not the construction of more equitable and egalitarian societies but rather the control of ethnical conflicts and the conservation of social stability.

Critical interculturality recognizes that differences have been constructed in a colonial structure where native people occupy the lowest part of the social order. From this perspective, interculturality is a tool and a grassroot process that aims for the transformation of structures and institutions in order to construct different conditions for being, thinking, knowing, learning, feeling and being. Critical interculturality implies recognizing asymmetries that exist when school science knowledge and local knowledge come in contact.

The need of an intercultural science education has been put forward by authors such as Aikenhead (2002) and McKinley (2011) as an inescapable need when the culture of those who learn are far away from the dominant culture. One of the most common approaches from this perspective has been the incorporation of local knowledge in the classroom (Aikenhead 2002), and the recognition that students have knowledge that could be related with the curricula in the design of teaching-learning activities (ie. Santos Baptista and El-Hani 2009). However, authors such as Carter (2004, 2008) warn about the danger when this type of interventions are undertaken without problematizing the role of indigenous knowledge, the reason it has been relegated in the classroom, and the relationship it keeps with dominant knowledge. This is why it is fundamental to look at these interventions from a decolonial stance.

Taking a decolonial stance would allow for an intercultural dialogue in the school that, according to epistemic pluralism (Olive 2009), incorporates, recognizes and values students' own knowledge and culture. This critical perspective allows us to reread texts that have been highly influential in the field of intercultural science education (Carter 2004) and point out how some of these approaches have a functional perspective incorporating local/traditional knowledge in the classroom without problematizing or recognizing conflict and asymmetry.

We need to rebel, take a stance that contemplates real conditions in secondary classrooms where students speak a language different from Spanish and where students have relevant knowledge that could be related to school knowledge. It is imperative to ponder what is the stance from where we are constructing activities that make intercultural dialogues possible and promote critical thinking that contributes to social justice.

2.2. Critical Thinking as Situated Practice

Different proposals have been developed to teach critical thinking in science in general, and in biology in particular. Some of them stress the development of argumentation abilities (Erduran and Jiménez-Aleixandre 2007). In recent times there are proposals that target the development of arguments about socioscientific issues that could be of interest to large segments of the population. Amongst them we find those associated to discrimination (Puig, Bravo Torija and Jiménez-Aleixandre 2012) and nutrition (i.e. advantages of vegetarianism, omnivorous diets and energetic costs, see Brocos Mosquera 2019).

In science education critical thinking has a privileged place. In a sense it is recognized as 'good thinking'. It lets students recognize weak arguments, inconsistent generalizations and non trustable asseverations (Harrison 2004). Critical thinking implies also a series of dispositions amongst which we can find: the search for intellectual rigour, conceptual clarity, and the desire to seriously consider other people viewpoints (Ennis 1996). Critical thinking is presented as a cognitive attribute that works as an identifier of the way in which we think more than of what we do and who we are, for example as a situated practice. In his research with indigenous university students, Harrison (2004) recognizes the easiness with which students learn to respond to teachers' expectations showing the characteristics of critical thinkers and keeping for them critical thinking as practice. Understanding critical thinking as a situated practice implies identifying its

exercise not only as ways of thinking but also as ways of acting which could be related to communitary commitments (Varelas, Martin and Kane 2012). Critical thinking as situated practice requires recognizing how thinking, doing, and living together can be incorporated in the classroom.

In Yochib (the community where part of this work is situated) teacher Lis points out:

Critical thinking in indigenous communities is bred from a different perspective, it incorporates how learning comes from modelling and recognizing wisdom. You learn through practice and by using all your senses to learn. You are wise according to how you live and feel well. Their quality of life is measured according to how you feel, to the state of your heart. This expression has different connotations, *lexil xchanel* (good learning), *k'uuxubinel* (considering others' feelings), *ich'elta muk'* (respecting and considering others). [In the community], good thinking generates good living³.

This good thinking demands an intercultural science education that supposes recognizing the 'other' and affirming oneself (Moya 2009 p.28). In this case, 'the other' represents school science culture incorporating the nature of science, the story of the construction of ideas, and the development of scientific abilities such as argumentation. In an indigenous school, affirming oneself leads to the recognition of a cultural identity: recognizing a common history, relations to the environment, worldviews, values, language, similarity of problems derived from exploitation, exclusion and social and economical marginality.

It is necessary to recognize how the very meaning of education is different in different communities. For Tsotsil people "education is conceived as a slow acquisition of the soul, which is analogous to a total conscience. Soul reaches maturity through learning how to become a good cultivator of maize"⁴. For indigenous people in Northern Canada, learning is a journey centred in participation: "The Eurocentric meaning of *to learn* becomes *coming to know* in most Indigenous contexts, a meaning that signifies a personal, participatory, holistic journey toward gaining wisdom-in-action" (Aikenhead and Elliott 2010 p.322, italics in the original).

³ Good living is a translation from '*buen vivir*' which is a common characteristic of the worldview of different Latinamerican indigenous people.

⁴ Taken from: National Institute for Indigenous People <https://www.gob.mx/inpi/es/articulos/etnografia-de-los-pueblos-tzotzil-batsil-winik-otik-y-tzeltal-winik-atel?idiom=es>

We need to question: What does critical (scientific) thinking bring to good (communitary) thinking? How are they related? How do we achieve critical thinking as situated practice?

2.3. Students' Knowledge, their Identity and Critical Thinking

Situated learning frameworks allow us to incorporate students' reflexive activity considering sociocultural context as inseparable of the activity itself (Lave 2009). From this perspective, the development of critical thinking always reconstructs the identity of the learner. The concept of identity turns out particularly useful for theorizing the relationship between individuals and their social world. Identity as a theoretical methodological framework has been interpreted in science education in different ways. We consider that identity is negotiated in a continuous reconstruction in our interactions and is mediated through language (Pozzer and Jackson 2015). Intersubjectivity and the development of funds of identity become relevant for such reconstruction (Subero and Esteban-Guitart 2014). Funds of Identity are inserted in the theory of subjectivity from a cultural-historical perspective where it is understood as a complex system articulated through the learner's life story, through her experiences in the different and diverse contexts in where she lives. These funds of identity are understood as the "resources that are socially distributed, historically accumulated and culturally developed that are essential for self-understanding, self-expression and self-definition" (Subero and Esteban-Guitart 2020 p.220).

In the social negotiation of identity, different situations allow for the emergence of moral contingencies where members of a community ponder through instituted and interiorized values and recognize themselves in decision making. In modern societies, this decision making is associated with the possibilities of self-determination and the development of a life project.

González-Escallón (2017) points out: "it is worthwhile to question the reason why self-determination of some individuals seems to produce no immediate effects that in other groups are taken for granted. An example is the case of homosexual persons whose life plan does not imply the benefits of heterosexual persons. Deep down, this implies that the right to self-determination is not guaranteed because they need to change their life plan if they want to have access to all the benefits" (p.171-172). In the same way, for indigenous students there is a dialectic relationship, established in a socially negotiated way, between their identity development, their self-determination capacity and the development of their

life project. This is associated with the possibilities they have to value their viewpoints, take decisions, planify, and develop their life projects.

3. Second Part. Yochib Students and Critical Thinking

In this second part we present data obtained from the exploration of the knowledge students have, that is valuable for their lives and that could potentially be incorporated into the classroom in order to promote critical thinking. Data comes from two sources:

- Students of the second author (in the secondary school in the community of Yochib) worked on aspects related to milpa for a four months period: describing diversity, cultivation techniques, animals and plants associated. After these activities the teacher posed two questions and students provided a written answer, that we analysed:
 - How do you feel about learning about milpa in your school?
 - Why do you think your teacher is dealing with these issues in the science classroom?
- A six hour workshop in San Cristóbal de las Casas, Chiapas, where we worked with teachers that attend schools in indigenous communities in different grade levels.

We use a situated learning theory (Lave 2009) to understand activity in context and an approach from critical theory (Johnson 2008) which aims to identify structures in science education that can originate or perpetuate inequalities and subordination relations and, from there, revalue forms and work traditions in the classroom. Through a recursive analysis in which we consider the whole of the data we formulate and discuss interpreted meanings (Erickson 2003). To illustrate relevant aspects, we use representative fragments of data. We present this reflection in a narrative way because our objective is to reveal the complexity of incorporating traditional knowledge in the classroom and explore the possibilities that this incorporation offers to develop critical thinking.

3.1. *The Value of Milpa as Source of Knowledge of Students*

In previous works we have explored the subject of milpa and its relation to school science. Milpa is a Mesoamerican policrop whose main components are maize, beans and squash. It has been recognized as an efficient agroecological system that profits from symbiotic relations among plants with other important species such as fruit trees, vegetables, chilies, as well as animals that live in such spaces. It has also been recognized as relevant to face

climate change (Boege Schmidt 2008). Milpa is fundamental to communities social life and is in the centre of ritualities and festivities (Carrillo Trueba 2016).

In activities undertaken by students in the classroom it is evident that they have a relation to milpa beyond its cultivation. This relation is emotional. This is why bringing the milpa to the centre of the educational act has not only cognitive implications. To the question: How do you feel about learning about milpa in your school? some students answer:

I felt very good and very happy because I want to learn about the milpa.

This is what I like to learn about maize. When I learnt I felt very happy because we are living with the maize.

In these answers we can glimpse at the value that the topic of milpa holds for students as it allows to bring to the centre of the curriculum something that is fundamental for them. When the teacher questions students about the milpa the traditional order in the classroom is subverted, modifying students' identity who, in this case, turn into teachers. Through the recognition of students' knowledge, learning becomes more like a dialogue where they can share traditional knowledge and cultural practices. Students become teachers or 'the ones who know'. There is a term in Tzeltal, *sk'oplal jbitewanejetik*⁵, which means the one who knows, and which is fundamental to indigenous pedagogy.

Milpa is clearly relevant for these students and allows them to have a voice in the classroom, an authorized voice that they can use to teach their teacher. We can show this in some of the answers to the question: Why do you think that your teacher is teaching about the milpa in school?

The teacher also wants to learn about maize to live. Also to cultivate her milpa.

Teacher wants to learn everything we do with the maize, maybe learn about the food.

It is worth noting that students consider this knowledge as their own knowledge, part of a larger system that we have called traditional knowledge. This larger system is

⁵ "The experience of those who teach".

also associated to their identity construction, for example, as a farmer that knows how to cultivate, as student Adelina points out:

My teacher wants to do all the questions. We are farmers and we know how to cultivate seeds of maize, beans, squash, chilies. We know how to cultivate, this teacher and the other teachers do not know how to cultivate milpa, but the people in Yochib know.

We understand traditional knowledge or indigenous knowledge as the knowledge that has been developed by people with ample histories of interaction with the natural environment and that originated independently from science in a particular cultural environment separate from occidental culture (Pérez Ruiz and Argueta Vilamar 2011). We recognize that students in secondary school are in a process of appropriating traditional knowledge in their community. In this sense, students' knowledge can be partial and incomplete but, nonetheless, important.

One aspect that teachers should take into account when bringing traditional knowledge to the fore is related to helping students recognize themselves in this formative process and visualize what it brings to school.

Even though this knowledge is relevant, it is also quotidian and therefore non-scholar. During the workshop with teachers one of their reflections related to the difficulty of problematizing everyday subjects. Antonio recalled about students telling him: "teacher, do not teach us about milpa, we already know that". From a decolonial stance we assume that frontiers between traditional knowledge and science, or between school and everyday life, are hybrid spaces and this recognition and the capacity to renegotiate and replace these boundaries as epistemological limits is deeply implicated in transformative global processes and demand a profound moment of postmodern reflexivity (Carter, 2008). This informs us about the relevance and complexity of transforming what belongs to the students in an object of study and analysis as well as problematising quotidian reality.

3.2. Fertilizers and its Potentiality to Promote Critical Thinking

In the question: Why do you think your teacher is dealing with these issues in the science classroom? Many students answered that the teacher was interested to know how a milpa is cultivated without using fertilizer. For example:

Other knowledge in our milpa is that I can not use fertilizer because it is poison, it is not good for the milpa, it is better that we work with our own hands with the hoe, in this way the corn will grow very big.

We can not buy transgenic maize because it uses fertilizers then it has poison. It is better to cultivate our milpas so we don't spend money and also I learnt to cook in my house. My mom taught me so we can eat.

If you give fertilizer it is possible that the plant dies, the teacher wants to know what is she going to do with maize. This teacher wants to know everything we do with maize, perhaps she wants to learn everything about the food.

In our milpa I can not use fertilizer because it is poison.

Not using fertilizer implies a political position that breaks the circle of dependence on industrial producers. Government and political parties have used fertilizers as a way of control and the dependency on fertilizer generates vicious circles, because the land impoverishes due to its continuous usage. Not using fertilizers can be related to identity and food sovereignty. This is why we found it relevant that it appears in students' answers in a recurrent way, opening a clear window for resistance and for the development of critical thinking. When students have such a stance, which is the role of teachers and school? Which is the relevant scientific knowledge related to this topic? What should students know in order to sustain their assertions about fertilizers and cultivation of milpa?

It is important to point out that while students in this particular school speak about not using fertilizers this does not necessarily happen in nearby communities (as was pointed out in the teachers' workshop). The debate on fertilizer usage is open in different communities and is a topic where school can provide elements for critical reflection. The development of critical thinking can not be thought in the void considering only the development of abilities and cognitive skills. Critical thinking in school should be useful for students to make decisions about issues that are relevant for their lives, congruent with their communities ways of living and thinking about the power relations that have been historically instaurated. Critical thinking should be useful to craft students' and communities' 'good living'.

3.3. *Critical Thinking and the Identity of Students in Yochib*

Yochib students relate the topics of fertilizers and milpa cultivation with their own identities and their life projects. For these students the development of critical thinking associated with these subjects implies a larger commitment beyond the school institution. It implies learning about what is relevant and has a place in their lives. Critical thinking, as we have pointed out, is not an abstract entity related only to thinking, it is thinking in action that will allow them to make decisions relevant for their lives.

Some of students' answers about the reasons why they are doing activities related to the milpa lets us affirm its potentiality and relevance:

The knowledge I have and I am still learning, will be very useful in my future of what I am going to do later in life when I have kids, husband and my own family.

Until I go out of my house, that is why milpa for me is my life because I eat from there and if I don't know how to work I will starve with my kids.

I feel very happy and proud to learn about milpa in the school. I like to learn about milpa, I like to learn how milpa is cultivated, how you sow maize, beans. But if we do not have terrain, we do not have where to cultivate even if we like to cultivate, just like those who do not have terrain (...) they are the ones that steal from us, they steal our maize.

If we want the maize to maintain us then we have to cultivate our milpa because milpa is very important for us to take care of our house. Milpa is very important because it is food, we can make tortilla, pozol, etc.

For these students this knowledge is relevant, not only for the constitution of habits of mind, but for their life, for their future. This is why knowledge that come into play goes beyond environmental and biological specific knowledge. Beyond knowledge that students can have about biodiversity in the milpa, this is relevant for their life and their future. We believe this is why it is imperative that students have spaces in the school to develop critical thinking understood as the possibility to interrogate their reality and, if possible, transform it.

4. **Third Part. Perspectives and Reflexions**

4.1. Collaborations and Future Work

During the workshop with teachers, they showed interest in working the topics of fertilizers and critical thinking. Teachers recognized this as challenging and as an uncommon approach in the classroom.

Following their interest, and with an invitation, the first and third authors visited two secondary schools. One of them is in San Cristóbal de las Casas (a large town and municipal centre), where students belong to indigenous groups but most of them do not cultivate milpa because they live in urban areas. However, these students have relatives that cultivate milpa and have regular contact with this cultivation. All of them speak Spanish but for some of them their mother tongue is Tsotsil or Tseltal. We also went to a secondary school in the small town of Aldama. In this community all the students speak Tseltal and all of their families cultivate milpa. During these visits we explored, along with the teachers, students' interests about fertilizers in order to use it as a resource for the design of didactical sequences. Students have many questions about fertilizers (Table 1).

Table 1. Questions that students pose about fertilizers. When students use fertilizers, they refer to industrial fertilizers, and when they use natural fertilizers, they talk about compost or products derived from their own crops.

About milpa and its growing	About fertilizers and the pollution
What can we do to make milpas grow well?	Why do we use fertilizers?
Why is it that sometimes they do not grow well?	What is in the fertilizer that makes plants grow fast?
Why do you sow beans near maize?	What happens with the milpa if we always use fertilizers?
What is the usage of maize leaves?	Are the fertilizers that they use on milpa good?
What kind of bacteria are there in milpa	Why are fertilizers bad?
	Are there non natural fertilizers that do not pollute the soil?
	Why is it that fertilizers damage plants?
	What happens when you are in close contact with fertilizers?

About the nature fertilizers and their production	About alternatives to fertilizers
What chemicals do fertilizers have? Are there chemicals in the natural fertilizers? What elements and materials are used to make fertilizers? How many different kinds of fertilizer are there? How is fertilizer produced? Which was the first country to use fertilizer? Who sends us fertilizer? Who created the fertilizer?	Why is an industrial fertilizer used knowing you can use a natural fertilizer? What can we do to stop using fertilizers? What is the difference in the growth time when using or not using fertilizer? Why aren't other things used? Instead of fertilizers?

Students establish differences between industrial and natural fertilizers. We can see an example of traditional knowledge associated to natural fertilizers in the description made by Rosa and Heidi:

To have a good crop without using fertilizers, before you sow your milpa you have to prepare the terrain and once it is clean your terrain you mix the soil with *gallinaza*⁶ or you can also put fruit rinds and peels and once they are rotten you give it in the feet of milpa. You can also make an organic compost with the leaves of the trees but they have to be dry, you put them together with cow maneuver and a bit of *pozol*⁷ and leave it to settle for a while.

The differences between industrial fertilizers and natural fertilizers are questioned by students when they ask if industrial fertilizers could not contaminate or if the natural fertilizers have a lot of chemicals. Listening to the questions made by students would allow us to generate an intercultural dialogue where traditional and scientific knowledge could come into play. Knowledge associated with plant nutrition, biochemistry needed to understand composition of fertilizers, water and mineral cycles, could have meaning if integrated from a dialogic perspective.

We recognize that it is necessary to design specific strategies to promote critical thinking and go beyond information delivery. Controversies are already present, for

⁶ *Gallinaza* is the maneuver of chicken mixed with soil, food residues and feathers.

⁷ *Pozol* is a traditional drink in the Chiapas Highlands, made from fermented corn dough.

example: between milpas' good growing and fertilizers' polluting effects; dependency generated by acquiring fertilizer from the industry and communities' self-determination.

Currently we are collaborating with some of the teachers in the workshop to design activities that consider their students' knowledge, their interests about fertilizers and their ways of being and knowing the world with the objective of generating dialogue spaces that promote decision making and justification. These activities will, on one hand, let us recover the experience of teachers in their work with indigenous students and, on the other hand, open spaces for in-service preparation and collaboration in learning communities. Activities will be used by teachers in their classrooms and shared and analysed in groups.

4.2. Final Reflections

We have tried to emphasize how critical thinking acquires relevance when topics in school are important for students, when knowledge is related to their own project of life and to their possibilities to construct a stance within the community, as well as taking decisions that have relevant consequences for life. After what has been developed in this chapter we want to underscore that science education is not only a sociocultural activity but a sociopolitical one "where issues of authority, power, and hierarchy affect social relations, access to ideas, and positionings that learners of a particular socially constructed racial group, ethnolinguistic affiliation, class, gender, and so forth, must negotiate" (Varelas Martín and Kane 2012 p.6).

We have stated that when introducing critical thinking in indigenous communities school and considering how, why and what topics are treated, we need to consider students' and communities' culture. To promote critical thinking, it is not enough with bringing into the classroom topics that are socially relevant, but these have to be situated and be relevant (or made relevant) for these particular students, underscoring what students bring to the classroom. Situations where these teaching situations occur are socially and culturally constructed and that is why the role of the teacher as an intercultural translator is very relevant (Santos 2019).

To promote critical thinking in the different communities there is not a ready-made recipe. We need to rethink and reinvent, bring cases such as the one presented to the arena for a collective reflection, aiming for research to help us think about different ways of being and contributing. In this case we have discussed about indigenous knowledge. However, this viewpoint can be applied in every case where inequalities have generated

the exclusion of contents, ways of thinking and even specific groups of students (women, for example).

The development of critical thinking should be related to knowledge, abilities, and dispositions that can strengthen good living, associated with individual identity development and the construction of life projects (Subero and Esteban-Guitart 2020). The objective is the development of individual self-determination: “the disposition to exert the capacity to elect between alternatives and, with a moral north constructed or individually chosen, each individual can take the moral determination according to her values and practices in an individual way” (p.169). However, these alternatives to choose are restricted by the possibilities that the community allows and that are considered acceptable. In this margin for election is where the school would be situated, trying to develop students' critical thinking in order to give them opportunities to identify the range of possibilities for action, and develop justifications for their elections.

This line of research, that aims to integrate traditional knowledge in the classrooms, promote critical thinking and develop decolonizing strategies is barely developed but highly relevant and challenging. Especially important would be that these groups of teachers with whom we have collaborated are consolidated, permitting that reflections and actions in the classroom come from the joint interests of a diversity of voices: academics, teachers, and particularly students and their communities.

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