



Narratives of learning in a permacultural cooperative: some inspiring ideas for science education in the light of Freire's pedagogy

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Abstract

In the last decades, agroecological and permacultural initiatives and organizations have grown. These initiatives attend to notions of food sovereignty and alternative models of agricultural production. The confluence of different actors and social initiatives through which experiences and knowledge of cultivating food are shared, and new ones are created, reveals a high educational potential. In light of impending global catastrophes such as climate change and pressing inequalities, new alternatives and diverse forms of sociability are necessary to open up possible futures for life on a damaged planet. Freirean approaches to science education must align with transdisciplinary social and political movements, and generate reflective practices and methods. This article addresses the case of an art and permaculture cooperative (APC) to analyze how communities work together to disrupt and dismantle inequities in science and education and make a more livable world. We offer a critical and contra-hegemonic pedagogical perspective on science education, one that forges new epistemic territories grounded in cooperation, art, permaculture, relationship, and diverse ecologies. The APC is the only one of its kind in Argentina. It has carried out its socio-ecological activities and interventions in ways that respect the characteristics of the natural ecosystem, agriculture and permaculture. We use narratives and case study methods to reveal how people's subjective narratives give meaning to their experiences and learnings. The APC as a learning context has the potential to transform reality, promoting the development and strengthening of popular science education for liberation, one that honors diverse ecologies, and meaningfully addresses new socio-environmental challenges and concerns.

Keywords Critical pedagogy · Permaculture · Community · Science Education · Environmental Education

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Resumen

En las últimas décadas han crecido las iniciativas y organizaciones agroecológicas y permaculturales, que atienden a nociones de soberanía alimentaria y modelos alternativos de producción agrícola. La confluencia de diferentes actores e iniciativas sociales a través de las cuales se comparten experiencias y conocimientos sobre el cultivo de alimentos y se crean otros nuevos, revela un alto potencial educativo. A la luz de catástrofes globales inminentes como el cambio climático y las acuciantes desigualdades, se necesitan nuevas alternativas y diversas formas de sociabilidad para abrir posibles futuros para la vida en un planeta dañado. Los enfoques freireanos de la educación científica deben alinearse con los movimientos sociales y políticos transdisciplinarios, pudiendo generar prácticas y métodos reflexivos. Este artículo aborda el caso de una Cooperativa de Arte y Permacultura (APC) para analizar cómo las comunidades trabajan juntas para interrumpir y dismantelar las desigualdades en la ciencia y la educación y hacer un mundo más habitable. Ofrecemos una perspectiva pedagógica crítica y contrahegemónica sobre la educación científica, que forja nuevos territorios epistémicos basados en la cooperación, el arte, la permacultura, la relación y las ecologías diversas. La APC es única en su tipo en Argentina. Ha llevado a cabo sus actividades e intervenciones socioecológicas respetando las características del ambiente natural, la agricultura y la permacultura. Utilizamos el estudio de caso y el análisis de narrativas para revelar cómo las narraciones subjetivas de las personas dan significado a sus experiencias y aprendizajes. La APC como contexto de aprendizaje tiene el potencial de transformar la realidad, promoviendo el desarrollo y fortalecimiento de una educación científica popular para la liberación, que valore las diversas ecologías de saberes y aborde de manera acorde los nuevos desafíos y preocupaciones socioambientales.

Palabras clave Pedagogía Crítica · Permacultura · Comunidad · Educación Científica · Educación Ambiental

I tear out the heart of time
 to find myself facing this second
 visceral, all-encompassing instant
 I settle in its vertiginous eagerness
 I drink its fruit and I invite you
 I encourage its swaying
 to palpate the alchemy of paths that unite us
 I glimpse how the bartering of bones signs us off
 how it charts a place for us in the fabric
 and with this kind of contemporary prayer
 I immerse myself in its ritual of transhumance
 where the offering, even a mystery, is perceived as linked to designing dawns
 to succeed each other in chance like galaxies
 and to know ourselves a little
 to spy on the infinite over the walls of the soul
 vain elasticizing attempt
 the tic-tacs of urgent pettiness
 this second amniotic shelter in the womb of the eternal
 volatile opportunity of the embrace
 explodes in genesis of notes
 and despite the orchestrated deterioration

this centre of the daily snail
atomizes us in constructions
in winds of feelings
recycling utopias once again.

Eduardo Linares

This article addresses the case of an Art and Permaculture Cooperative called the ‘Reciclando Utopías’ (hereinafter APC), understanding it as a learning context linked to science education and the environment. Before becoming a cooperative, the idea of ‘Reciclando Utopías’ (Recycling Utopias) started as a poem that, once the constitution of APC, became a song. As we can see when reading the poem, ‘Reciclando Utopias’ is not only a poetic thought expressed in words; it is an action that crystallizes in a collective that seeks freedom and social, emotional and environmental transformation. This study aims to understand the educational potential of the APC by addressing the learning processes that take place within the community, and the experiences and perspectives of its members. The APC, and our analysis of it, has generated new ideas and sparks of inspiration for science education, which we share with you, our readers, in this article, in the name of building a more socially and ecologically just world.

Theoretical framework

Science education, Freirean theory and ecology of knowledge

In Science Education, given the complex interfaces and relationships between science, technology, environment and society, a paradigm shift is required. Considering the social and political imperative for a more sustainable, social and environmentally responsible action-oriented society (Zoller 2013), the development of new ideas and models for science education is high-priority. In particular, in the face of impending global catastrophes such as climate change and pressing inequalities, Tolbert and Bazzul (2017) have called for a science education that aligns itself with transdisciplinary social and political movements to generate new possible futures for life on a damaged planet (see also Bazzul and Tolbert 2019). Others have also underscored the importance of building social, environmental, culturally pluralistic, just and sustainable futures in/through science education (Kayumova and Tippins 2021).

Although, traditionally, disciplinary scientific knowledge and practices provide models for understanding worlds, they are still largely ideologically conservative. As such, these traditional models are insufficient for contributing to social and political dimensions of environmental crises; yet, it is impossible to disentangle science from the social and political. Therefore, educators must break with restrictive institutional practices that refuse to engage with sociopolitical dimensions of wicked socioscientific problems (Tolbert and Bazzul 2017). For science education, that means examining the stories we tell in and about science, while inviting new forms of questions and new creative answers to them. Most importantly, we must come to terms with the fact that we have been teaching only partial and biased knowledge, under the guise of ‘objectivity’ (McCausland 2020).

According to Freire (2015), education as a practice of freedom is manifested when educators and learners responsibly self-configure their experiences, express their judgments, and (re)discover themselves as builders of their own destiny. A pedagogy of liberation

is mediated by reflective practices and methods of creation and recreation (Freire 2015). What does this mean for science education? From the standpoint of education as a practice of freedom, a more comprehensive conception of science and science education is needed: one in which knowledge construction occurs in social, historical and cultural contexts, one in which actors collaborate and mobilize for informed, participatory and action-oriented citizenship, and one in which actors demand social and ethical justice (Reis 2021). Given these considerations, we find that the ecology of knowledge (de Sousa Santos 2010) is an interesting theory to consider. Contrary to a hegemonic conception of science, borne of modernity, Boaventura de Sousa Santos's concept of an ecology of knowledge(s) can be understood as a counter-epistemology that recognizes the plurality of knowledges and the interconnections that exist between them. The ecology of knowledge promotes the dynamic conjunction between scientific and non-scientific knowledge because de Sousa Santos (2010) considers different ways of understanding matter, life, society and spirit. In addition, de Sousa Santos (2010) proposes that knowledge is, in reality, an intervention and practice. In that respect, an ecology of knowledges has a pragmatic character. In other words, ecologies can be understood as actions of mutual encounter and reciprocal dialogue that sustain the reciprocal fertilization and transformation between knowledge, cultures and practices that fight against oppression (de Sousa Santos 2019). We apply de Sousa Santos' ecology of knowledge to illuminate the possibilities of a hybrid knowledge system that includes environmental education, science education, and permaculture.

Social participation and permaculture

Currently, participation in various initiatives and movements, such as non-governmental organizations, citizen assemblies, work cooperatives, and volunteer programs, related to both local and global socio-environmental issues, or in defense of animal rights and other living beings, is growing. These types of initiatives have clear politically transformative potential. However, we also reflect on how such communities are spaces where new and existing relationships and knowledges are shared and built, both within the community and in interactions outside of it (Palombo 2021). Pedro Reis (2020) considers that participation in such organizations empowers citizens as producers of contextualized and socially relevant knowledge, rather than consumers of information that may or may not be relevant. In terms of the pedagogical potential of these spaces, new members are invited to develop their power of capturing and understanding the world through being in community with others working for change. Such communities also have real potential to disrupt what Paulo Freire has referred to as the banking model of education, where the teacher is knower and student is learner. Instead, all participants experience a pedagogy where the world is presented to them not as a static reality, but as a reality in transformation, in the making (Freire 2015).

In response to the global environmental crisis, in the last few decades, various initiatives and organizations have emerged around agroecological and permacultural production (Ferguson and Lovell 2014). These initiatives address issues of food sovereignty and provide alternative models of sustainable food production. We also note the confluence of different actors and social initiatives such as family producers, agroecological fairs, and formal and non-formal educational institutions, where experiences and knowledge are shared, and new ones are created, in pursuit of environmental care and the promotion of agroecological and native forest production (Palombo 2021). María Barba (2019) highlights a great educational potential in such organizations, particularly for the environmental education

movement. Barba posits that environmental education as a social movement should be integrated within a project of social change, a collaboration with diverse groups that actively position themselves against an environmentally uncomfortable reality and seek the construction of other possible futures (Barba 2019). Environmental education can be politically understood as a social movement that arises in reaction to the hegemonic development model linked to a neoliberal system. Its radical potential lies in the concretion of different activistisms that situate environmental issues as the object of their struggles. Environmental education, therefore, can become a springboard for social change and for the construction of sustainable alternatives, such as the permaculture movement. Nelson Lebo and Chris Eames (2015) also identify an emerging need for new educational approaches that cultivate relationships between science education, environmental education and permaculture.

Permaculture emerged in the mid-1970s through the work of Mollison and Holmgren. Tired of protesting against environmental degradation, Mollison was determined to develop a solution-oriented approach to environmental protection, with an emphasis on sustainable food production (Ferguson and Lovell 2014). The term permaculture comes from the words ‘permanent’ and ‘agriculture,’ representing an interest in perennial crops. Permaculture is a holistic design system based on direct observation of nature, combining ancestral knowledge with findings of modern science. It is an eclectic and adaptive approach to food production, emphasizing local–regional and practical perspectives. In a broad sense, it is a philosophically based global practice and is considered a ‘sustainability movement’ in its own right that encompasses a set of ethical principles, design guidelines, and techniques for creating sustainable environments, permanent culture, and ecological responsive agriculture (Maye 2018). A central aspect of permaculture is the design of ecological landscapes for food production. As the emphasis is on design principles, there is no specific method of food production; it is also called ecological agriculture –popular production systems commonly associated with perennials, agroforestry, organic systems, forest gardening and polyculture (Ingram, Maye, Kirwan, Curry and Kubinakova 2014). These contra-hegemonic forms of agriculture are frequently associated with groups or networks who seek sustainable alternatives to industrial agri-food systems and who question the sociotechnical regime built around industrialized agriculture (Ingram and Maye 2017).

Because embedded in permaculture design are themes and practices of science and sustainability, some authors postulate that permaculture is ideal for teaching about science literacy: ‘education through science’ rather than ‘science through education,’ or ‘science education through permaculture’ (Lebo and Eames 2015). Using the context of local and sustainable food production for science learning can lead to growth in students’ scientific and ecological literacy, as well as increased positive feelings toward both science and the environment (Lebo and Eames 2015).

Popular-democratic education and cooperativism

Paulo Freire’s pedagogy emerged from Latin America, and has since been taken up across the globe, particularly to those parts of the world where oppressive contexts and regimes necessitate a collective and popular educational response (Freire 2008, 2018). Such Freirean educational responses must be grounded in the local needs and struggles of oppressed communities and must not remain only theoretical and/or indifferent to the immediate needs of the people, specifically in terms of the need for local sociopolitical action (Freire 2004a). Megan Bang (2020) also argues that the construction of new sustainable worlds through education must be informed by a robust understanding of complex

socio-ecological systems, including learning and human development and the development of locally based socio-ecological literacies. From this viewpoint, it is relevant that educators are increasingly open and flexible from a scientific, social, political and emotional perspective, which implies knowing the specific world in which the learners live and, at the same time, broadening the perspective of where learning occurs.

Paulo Freire (2004a) affirms that in democratic education whoever teaches also learns. When teaching, the educator recognizes previously the learner's prior knowledge and, by closely observing the learner's curiosity, the educator can help the learner recognize doubts, successes and errors. The educator plays a key role in supporting the learner on their journey to discover themselves as a historical subject, and transformer of their own destiny. The main theoretical developments in cooperative education derive from critical pedagogy since, from the origins of modern cooperativism, there has been a clear link between cooperativism and popular education (Mata Diestro 2020). Both cooperative education and critical pedagogy were developed in regions of the world where the situation of subordination and oppression served as a substrate for a democratic and liberatory education. Shared characteristics between cooperative education and critical pedagogy include the recognition of the political nature of education, the denunciation of the factors of alienation around economic and political injustices, and the focus on the transformation of reality (Tifni 2010).

The purpose of this paper is to understand the educational potential of permaculture learning by addressing the learning processes that take place within a permaculture cooperative. The case of an Art and Permaculture Cooperative (APC) is illustrated to reveal how permaculture communities (and other similar socio-ecological communities) can work to disrupt and dismantle inequalities in science and education and make a more livable world. We aim to illuminate new epistemic territories in/for science that value diverse knowledge, relationships and ecologies, and contributing to a critical and contra-hegemonic pedagogical perspective in science education.

Methods

Our research is presented as a case study (Stake 1998); here, the case study is the approach employed to understand the APC as the particular case of our interest. Our focus is on documenting the APC members' subjective narratives, in order to better understand what we might learn from them. Our critical pedagogical approach, therefore, is reading the world through the APC members' narratives, in order to co-generate, with APC members, new epistemic territories that can transform the world(s) of science education.

Data collection

Observations and interviews were performed on site in context, at the APC, during related activities (described below). All observations were carried out at different APC activities and meetings, such as the work in various agroecological fairs and at the APC seat/headquarters. Four members were interviewed: the president, the treasurer, a regular member and an external participant who participates in the cooperative and is recognized by the rest of the members. Interviews with the president and the treasurer were performed in the APC headquarters. The regular member was interviewed at the Agroecological Fair held every Wednesday in a neighborhood in Cordoba city, Argentina (see below). The external



Fig. 2 Sales stands in the agroecological fair of Cordoba, Argentina. December 2021. Photos by: Ezequiel Ambrogio

personally experiencing the effects of deforestation and indiscriminate logging in the space that was their home. In response, they created a theater play about Argentine mythological beings that tells the story of an environmental problem, as recounted by a tree; this was a culminating moment for the community, as they began to see themselves as ‘thinking artists-activists’ in the fight against climate change, deforestation and threats to their water supply (Freire 2008).

The APC conducts their activities in harmony with nature, where the forest is the ‘school’ (translated from the Spanish ‘el monte es escuela’), and an intrinsic source of knowledge. The forest is a place where creative ideas around art, good living and food sovereignty are inspired and actualized. Currently, the APC performs a variety of artistic and bioconstruction services and food productions. The artistic interventions involved murga, artistic make-up (e.g., at children’s parties with an agroecological perspective), and the organization of and/or participation in a range of cultural events (social economy and agroecological fairs), as is described in Martín, Donolo and Cugini (2020). They also design and produce sustainable goods: natural cosmetics, natural first aid kits, textiles, and provide educational support, such as growing and preparing agroecological food (pre-mixes for soups, recipes, cakes and bread), seed production, and permaculture workshops (Fig. 2). They work on several proposals based on bioconstruction. Bioconstruction is a form of construction that respects living beings and the environment—expanding the idea to sustainable architectural styles, where the main concept is adaptation and respect for the cycles of nature, considering climatic factors, geographical conditions, lunar cycle, etc.

These proposals include sanitation systems, dry toilets, clay ovens, green roofs, water collection systems, mud walls, among others. One of the recent bioconstruction initiatives that the APC has carried out is a fully permacultural house, considered an ‘ecosystem,’ that includes fresh water, clean energy, solar kitchen, green roof, orchard, a chicken coop, integrating consumption habits for sustainable living (for more details, see Martín, Donolo and Cugini 2020).

As part of another initiative, the APC created the CAPARU store (Food Centre of Agroecological Productions Recycling Utopias), the seed production garden, and spaces for community and collaborative encounters such as La Pachita -a geodesic dome and a natural amphitheater. It is worth mentioning that as a result of the APC work during the last eight years, Ñu Porá has successfully implemented a zero-waste action project, and over the past few years has learned about and implemented the three Rs of waste management: reduce, reuse and recycle. Other proposals to integrate green or alternative technologies have also been developed and implemented, such as the smoothie bike (stationary bicycle that harness the cyclists pedaling energy to mechanically power a blender with fruits and pure fruit juice) and the dry toilet (a toilet that operates without flush water, used to save water and prevent pollution), both also exhibited at the Agroecological Fair (Figs. 2, 3).

In terms of management, the APC is part of the Associative and Social Economy Board (MAyES) of the National Institute of Associationism and Social Economy (INAES), as well as part of other various community participation projects related to food sovereignty



Fig. 3 Activities during the celebration of the 8th anniversary of the agroecological fair of Cordoba, Argentina. October 2021. Photos by Ezequiel Ambrogio

and social and circular economies. The APC is also a member of the assembly and commissions of the Agroecological Fair of Cordoba—a type of farmers’ market where people sell organic foods and homemade products every Saturday (Fig. 3). The Agroecological Fair was originally established to address the economic and social vulnerability of agroecological food producers, permaculturists, and other small farmers, to increase the supply of locally grown organic/agroecological produce in Cordoba city, and to raise awareness about the importance of consuming healthy foods.

The APC context and background

This section emerges from the APC member’s narratives. As they narrated their experiences, they pointed out some socio-environmental struggles and tensions that occur in Cordoba, and particularly, in the town Rio Ceballos. We first provide some regional context to situate their narratives. The new capitalist food production and distribution strategies pursued by agribusiness aim to exploit the riches of the soil through the manufacturing of products for global distribution (Cáceres 2015). Cordoba Province, in central Argentina, is one of the most dramatic examples of this reality: the processes of agribusiness expansion in the north of the province, between 1970 and 2000, caused the loss of more than 10,000 km² of forests. The high prices of land driven by the high prices of agricultural products have favored the concentration of land in large properties for production, which in Cordoba has caused some of the highest rates of deforestation in the world (Cabido and Zak 2010), and is currently one of the Argentinian provinces with the largest deforested area in areas of high conservation value (Vallejos, Sans, Aguiar, Mastrangelo and Paruelo 2021).

In 2012, Sierras Chicas and Punilla inhabitants (where Rio Ceballos and the APC are located) rose up in protest against the environmental disasters resulting from deforestation in the local basin within the context of increasing and uncontrolled urbanization. Then, during the 2008–2013 drought period, the approval of the construction of several gated neighborhoods and the corporate grabbing of thousands of hectares of forest for mining purposes angered local communities (Deon 2021). This urban expansion advances on hill-sides with steep slopes and in high areas; they also headed west, in areas of the foothills of the mountains on sectors belonging to water basins such as Ñu Porá. These processes of territorial transformation advanced over rural and natural areas of high environmental fragility (water basins, stream beds, mountain slopes, nature reserves). The urban expansion has been detrimental to the area’s habitat and mountain landscape, and has resulted in a loss of ecological services and natural commons. Thus, a continuous environmental imbalance has manifested that includes the loss of plant cover and soil, water supply problems, runoff, conflicts with sewage effluents and loss of landscape quality (Becerra 2019). In addition, in recent years, there have been devastating fires in grasslands and mountain dry forests (Argañaráz, Cingolani, Bellis and Giorgis 2020), prolonged droughts and catastrophic floods during 2015–2016 (Chiavassa, Ensabella and Deon 2017). It is a complex and dynamic territory, where environmental problems have been getting worse year by year in a context of global climate change and inadequate local public policies.

In this context, power relationships around the use of land and water generated socio-environmental conflicts, through which citizen assemblies and social movements came to organize their resistance, as part of a collective counter hegemonic response to the ongoing conflicts (Deon 2016). In Sierras Chicas, social organizations and activist, intermediate institutions (such as cooperatives) and some municipal public agencies have also joined

movements and organized, working to establish connections with other groups who share common goals. As discussed in Chiavassa, Ensabella and Deon 2017, these different actors work to implement joint actions in defense of the local environment, by working together on the environmental issues of Sierras Chicas, in pursuit of sustainable development. There has emerged a confluence of actors around a collective struggle for rights over water, land, forest and local identity (see also Deon 2021; Ensabella and Chiavasa 2019). Immersed in this context, the APC members became aware of the need to drastically modify their lifestyles, and make deeper connections within the local community in pursuit of care of their local environment and territories, and to promote and participate in a variety of actions and initiatives, which have transformed their reality. In the next section, we share our analysis of their narratives.

Interpreting narratives from members of an art and permaculture cooperative

In our analysis of the APC members' narratives, we draw from the central tenets of critical pedagogy, such as democratic education, freedom and lifelong learning, as well as theoretical concepts, such as the ecologies of knowledge.

Learning and democratic education

Knowledge is co-constructed in the APC. The APC as an educational project is an intervention in worldmaking, dreaming for new sociopolitical and ecological realities, and a 'science of practice' in search of making its participants more human. Food is co-produced daily, and all reap the benefits—both inside and outside of the cooperative. Cooperative members are engaged and participate as agents of change. In the context of the APC, teaching and learning occur simultaneously; each participant is recognized as having a body of knowledge that will enrich everyone. Permaculture involves cooperation, and cooperativism pursues those same principles (although it is true that not all cooperatives truly enact it). Theorizing from a permaculture cooperative, the field of science education must similarly become a welcoming endeavor, characterized by democratic participation and listening to others. This must emerge from a commitment to respect for others, driven by what is best for the collective, where the common good, freedom and emancipation prevail. APC members comment on the collective and participatory nature of the cooperative:

APC was founded as a work source, from a cooperative perspective and, at the same time, to create jobs. Why? What do we do? We do the shopping in common, a large purchase among a group of people, grains above all, for the grain milling machine; and at the same time, it is also like we say "well, let's delegate who can do this". In this case, I am the one who says "well, I am in charge of milling the grains" because I have the smoothie bike, and I take the smoothie bike to grind the grains, pack them, label and take them to the fair. Sometimes I do it alone and sometimes I do it with a partner or with someone who can help me, but there is already an economic organization (...) Some people are around, who support you, who want to do something when a task comes up, there are a lot of people who are working for that and we work a lot, and those people work harder than oneself (Narrative of APC member).

As we mentioned previously, the APC also organizes and leads educational workshops for APC members as well as the public. Some workshops are related to permaculture in everyday life and in diverse contexts. They enact a broader vision of science, breaking with traditional forms of science education that focus on learning canonical science concepts, toward a science education that is concerned with the empowerment of citizens within a democratic and collaborative process. The APC members invite us to reflect on alternative educational spaces, through which more expansive and socio-politically transformative science knowledge is built.

In the words of Freire (2004b), we need to build a less ugly and less aggressive society, in which we can be more ourselves. Seeing oneself as a subject of learning is often incompatible with pragmatic education training, implicitly fueled by authoritarian elitism of those who believe themselves to be masters of truth and knowledge. Building social and political solidarity requires that all individuals in a community participate in and bear the consequences of collective decision-making, including decision-making about what and how to learn. This is, in part, about humility. Humility and solidarity go hand in hand. The more solidarity there is between educators, learners and the various participants in a community, the more the possibilities for democratic learning become apparent. The APC treasurer mentions that she is always learning in the daily and collective permacultural practice:

So, well, I learn all the time: doing, trying, getting it right, making mistakes and also with much humility and listening to each person I come across and taking many workshops, also (...) The ways of learning are very diverse, and for example, the fair is also a nice learning place. The [lesson learned from] meeting with each peer is that life is continuous learning all the time, and more so now that we are living here, so we are not spread out in physical time. (APC Treasurer)

Humility, according to the treasurer, is learning all the time by listening to others. In this respect, she expands her personal truths through teaching and learning with others.

Another APC member comments below on the knowledge that he builds in relation to others:

Nowadays, my training happens through learning about food, permaculture, nutrition (...) And along the way, you meet many people who have already had the experience. (...) You train yourself from cooking with grains or probiotic food, fermenting, modification, we go as a group of people from many workshops of certain things appear, then you are training (...). It is integral, you say "well, let's see, I want to see"; you simply watch a video and learn some things, and then you start.

I think it's all this because it's constant training. I mean, I don't think we stop receiving information. When you get into it, there will always be something, from medicinal plants, then you want to make microdose or make natural oils. I think that education is the axis, I mean, it is also like you are always in a continuous learning process and, at the same time, you are transmitting it. (APC member)

Learning is constant action and reflection. This unending search and curiosity about oneself is education as the practice of freedom (Freire 2008).

Practices for and in freedom

In the search for liberation, self-transcendence occurs where everyone grows together. Individuals come to understand themselves as part of a reality that is no longer static but

in transformation, being shaped by the collective and as individuals within the collective (Freire 2015). As another APC member mentions:

We made murga, statues, et cetera. If we danced in the street, it was for freedom. We didn't have money, and we didn't dance just for money. We had the indecision to say: "I don't have money, but I'm not going to dance just for money. I do it for freedom". And now the same thing, we choose everything for freedom. We have no idea of what we will be doing later on, and at the same time, we do. Now we are at the moment of beginning to integrate all this. (APC Treasurer).

A shared conception of freedom grounded in a desire to become more fully human, becomes a way to move beyond oppression:

As I see that, I think it is more essential than important. I have been working as an employee for many years since I was very young, so nowadays I think it is essential, I mean, that one has to, that one can learn to support oneself in that way, to stay in that place because it is a way of life. Let's say, I think that this appropriation regarding life, regarding everything, also has to do with these tasks that one carries out. If you do not do what you want, where will you find happiness afterwards? There are people that I hear "now that I can", "now that I have these days off", you see? It sounds very strange to me, you see? (APC member).

Freire (2015) conceives of freedom as a conquest that demands constant searching. In other words, freedom requires critical awareness of the oppressive situation and then, following that awareness, an action that transforms reality, resulting in a different situation that allows an individual, and a society, to make and remake themselves—and through that process, reimagine society.

When you understand that 'Pacha' ["Pachamama" or "Earth Mother", a goddess revered by indigenous people from the Central Andes and still admired in our modern nations] is your home, you no longer have to have 'your [own] garden' to plant. Where you are, you will sow or you will generate things in pursuit of that, about that. For plants, [they will do this] anywhere in the world. It is remembering, we all have it, it is not that it happened to me, you have to open up to remember. Food has done a lot for us, we would not have made all this change if we had not eaten at least 80% without pesticides. We participate in community purchases every six months of all organic products. The grain premix came up as a thank you for all this. We looked, and we all had pots of beans, chickpeas, et cetera. And we saw everything organic, and we said, "we are very privileged", and we said, "so that there can be more privileged people we have to give thanks for this". But not just saying "thank you, thank you", but doing something. (APC Treasurer).

The APC treasurer demonstrates gratitude as a practice of freedom; gratitude is an act, not just words. Freire (2012) has also stated that it is necessary to fight to maintain life, while at the same time he believed it impossible to suppress the fundamental core of all life: freedom and the fear of losing it, communicating freedom as movement or constant search. The core of life is understood broadly—and not unique to human life alone. Freire (2012) also argued that life-denying practices—human practices that contaminate the air, waters, and fields, devastate forests, destroy trees and threaten land animals and birds—contradict a progressive, revolutionary discourse.

From her narrative, the APC treasurer points out that many of the problems in the community originate around water. Permaculture as a way of life for these communities lies in

giving it a unique value and putting words on it. She strives for a reflective and liberating life-giving practice, through permaculture.

Actually, there is water, it is a lot. The point is to learn to harvest it, learn to value it and cycle it all the time. There is no water here that is not used twice, three times, four times. Now it doesn't enter my head, and the truth is that this is learning because it's not something I did before. Being at such an extreme level that you depend only on rainwater, here I can't water that amazing lettuce that you see with water, just grab the water and water the lettuce. I have to find something to do first with that water, wash a dish, wash clothes, and then water... and I can do it because I know what I wash with, and I know why I learn, learn, learn, and if I don't know, I look, and I learn (...). In everything I do, I am learning. I wash dishes and I learn. I go to the bathroom with the dry toilet, and I learn. I try something else and I learn. So, learning, when you're open, I think it's all the time. (APC Treasurer)

Learning and doing science occurs as part of the everyday activities, practices, meetings, and dialogues of the APC. The activities of the APC are rich contexts for scientific practices such as critical thinking, argumentation, and constant inquiry, and sustainable engineering such as bioconstruction (Perroni Gasull, Sago Herrador and Martín 2020). These are not just teachings and learnings, however. They are a way of life, in the name of freedom and transformation:

So, nowadays, in the Cooperative, we have a wide range of possibilities. We can do different things, from gardening, bio-construction, animations, recreational workshops, sustainable energies and much more. (...) to this, we started to implement, through this, a smoothie bike to make fruit drinks. So, what is the purpose of this? Show that there are energies that are not the best known, which are renewable energies. (APC member)

Then bioconstruction appears. We also do it a lot from that place, of permacultural developments, a space for taking advantage of space and not generating this, right? They have to have air conditioning because they do not have enough electricity supply to heat... (APC member).

Co-construction of ecologies of knowledge(s)

The concept of ecology of knowledge recognizes the plurality and dynamic interconnect-edness of heterogeneous knowledge—beyond dominant western scientific knowledge. Knowledge is inter-knowledge, formulated and viewed from an intercultural perspective. In this regard, an APC member defines permaculture as a conjunction, an ecology of knowledge:

Innovation... recovering knowledge because it is not something new, it is not something that comes up at the moment (...) And it is very unusual what you say, isn't it? Because sometimes you could think "ah, look, I am going to do that," but no, you go back to the simplest thing; and you are doing that, innovating, how am I innovating? If this is the oldest matter, the first thing that existed, that is permaculture for me. If I define it, for me it is recovering knowledge [vs. innovation] (APC member).

As the APC partner expresses, recovering traditional knowledge and everyday learning are inherently valuable interventions in the world. Within these interventions lies the importance and preservation of biodiversity, made possible by rural and indigenous forms

of knowledge. These forms of abundant knowledge have cultivated and preserved ways of life, symbolic universes, lore and wisdom, based on tradition and oral narratives, in order to survive in hostile and novel conditions (de Sousa Santos 2010). These forms of knowledge can be understood as human interventions that move away from neoliberal capitalism and dominant frameworks of western science, toward a knowledge and practice of being and becoming in the world. The following excerpt describes how members of the APC, especially at the APC headquarter, use and reuse only rainwater, with the aim of taking care of natural resources:

You get to see that, and you realize that the water cycle is the only way to complete it otherwise you don't complete the water cycle, and you don't do anything to complete it. If you complete a cycle of anything else, water is a living being. As soon as you understand that water is a living being, you start to think differently. You are not washing your hands; they are washing your hands. There is another version, another vision, which is to put yourself on the other side of what is happening. It is all mirror, mirror. It is real, what you are observing is observing you, and when you understand that it is watching you, it gives you all the power. It is all very beautiful, to realize, to keep the prudent thought. To keep the poetic thought, to get to think poetically. When you start to think poetically, you realize other things and it is not romantic. It's a post, it's real, it's pure magic... (APC President).

Thinking and feeling the water as a living being is not a 'scientific' idea. It arises from the practice inspired by other worldviews or *cosmovisiones*, and the notion of 'Pachamama' as protector and provider of water and food, leading to a more 'human' approach to nature and the environment. This implies a shift in perspective more linked to the affective, to learning by doing, in context. In the words of Lebo and Eames (2015), a contribution to think 'education through science' rather than 'science through education.'

The APC members demonstrate the pragmatic nature of the knowledge they co-construct, the concrete applications that this knowledge can offer. That constitutes one of the pillars of the ecology of knowledge. The participants are self-organized, share goals and interests, and learn together to create new ideas and innovative practices. This perspective illuminates the value of a pluralistic science and alternative scientific practices, such as the rich learning that occurs among the APC members while carrying out their daily activities.

Educational practices and permacultural cooperatives with emancipatory horizons

The APC as a learning context may have the potential to transform reality, through permaculture and cooperative education as a vision for a liberatory scientific education. The APC is built from an ecology of diverse knowledge that can help address new challenges and socio-environmental problems. We hope that the work we have presented offers some sparks of inspiration. We hope that we have revealed how social participation in recuperated knowledge builds utopias, and reinvents societies, in the sense of making them more human (Freire 2018).

APC members state that they are constantly learning about science through permaculture, and vice versa, participating in a continuous process of reflexive and dialogic democratic education. Education as a practice of freedom in the APC happens as members bring their individual experiences and hopes to bear as part of collective

decision-making and, through the collective, come to perceive themselves as builders of their destiny; that is to say, participants discover themselves as historical subjects and transformers of their realities. Education is the means by which participants deal critically with reality and, collectively, discover how to work together in the transformation of their world. As expressed in their narratives, the APC members have also chosen a way of life centered on the integration of nature and culture, grounded in permaculture principles. The APC, in its daily practices, is in itself an act of resistance to the exploitation and contamination of water and land in the surrounding territories. APC members transcend their situations of subordination, through a collective commitment to liberation.

APC participants benefit from the sharing of multiple and diverse forms of knowledge, e.g., between scientific knowledge and other social, popular, artistic, peasant, indigenous knowledge. The democratization of learning from diverse knowledges supports the creation of positive and reciprocal relationships among community members and with nature. The ecology of knowledge represented within the APC also allows members to connect more deeply with the social and emotional aspects of their work, as well as with personal experiences and everyday knowledge. By enacting an ecology of knowledge, the APC re-affirms different epistemologies as valid (de Sousa Santos 2010).

Permaculture is a way of life, but also a way of lifelong learning (Martín, Donolo and Cugini 2020). Permaculture unveils nature-culture practices that can help communities overcome social inequalities and environmental problems. Permaculture goes hand in hand with cooperative education, which can be understood as a way to improve relations between workers for social transformation. We have illustrated how permaculture and cooperativism are a form of critical pedagogy. The APC is a collective organization seeking social and ecological transformation through art, culture, and agroecology.

Freire continually invites us to think about what teachers should know and what they should do, especially when the emphasis is on educating to achieve equality, sociopolitical transformation, and the equitable and just inclusion of all people in society. For him, education and its radical potential to improve humanity are fundamental in his conception of liberation and social inclusion (Freire 2004b). Much remains to be done to support citizens' informed participation in decision-making and action on issues that affect our societies and communities (Reis 2021); it is necessary, therefore, to consider ways to enact more democratic and dialogical projects and initiatives. What are the implications for science education? We must wholeheartedly reconstruct the world of science education, and challenge neoliberal ways of relating that have dominated the field (Torres Olave and Bravo González 2021). The case of the APC invites us to examine dominant and non-dominant stories that are told in and about science. Reflecting on the potential of a permaculture cooperative as critical pedagogy for science education can spur dialogues about how science education can support more sustainable futures (Hadjichambis and Reis 2020). One way to enhance the social and cultural relevance of the curriculum and to confront neoliberalism in science is through the generation of places of hope, such as enacting a vision of activist science education for social and environmental justice (Torres-Olave and Bravo González, 2021). In other words, science education should not only be about analyzing how science has impacted or affected the world, but also about transforming the practices of science (and science education). We appreciate the pedagogical potential for these forms of critical hope in the stories told by the APC members about their engagement and activism in art, environment, science and education, and the ways they have inspired us to reflect on transformative possibilities for science and education.

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