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Reverse impact: Co-constructing mathematics education with communities facing socio-environmental crises

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Pedagogical alternatives that bring communitarian knowledge into the mathematics classroom are fundamental in struggling communities because mathematical knowledge is a tool for understanding social reality in the face of a crisis. However, adopting a communitarian approach involves severe epistemological challenges, such as the democratisation of knowledge. Here we share our reflections about knowledge democratisation in a project that aimed to create an educational proposal for communities that struggle with socio-environmental crises in Mexico. We emphasise the tensions and insights that emerged in our attempts to build a horizontal collaboration with teachers and how this collaboration impacted our understanding and enacting of a communitarian spirit to mathematics education.

Keywords: Communitarian pedagogies, knowledge democracy, environmental crisis, critical mathematics education.

Introduction

Who knows how to teach mathematics? There is an increasing interest in challenging the view that experts working in academic institutions and the government are the only authorities that should dictate how mathematics has to be taught in the classroom (Civil, 2002a; Skovmose & Valero, 2010). This view can sometimes contribute to perpetuating the conditions of disadvantaged communities. Therefore, pedagogical alternatives that integrate the knowledge of communities with academic knowledge are necessary for building equity in education (Civil, 2007; Fals-Borda, 1991). From a critical mathematics education perspective, community-based pedagogies can offer students insight into the role of mathematics as a toolbox with resources for interpreting and transforming social reality. This toolbox is essential in struggling communities because mathematical knowledge can facilitate ways of understanding and act in the face of crisis (Skovmose, 2021).

Nevertheless, adopting a communitarian approach to mathematics education involves finding practical solutions to serious epistemological challenges, such as the democratisation of knowledge. There is an inherent complexity in mediating between researchers' "expert" knowledge and the specific knowledge teachers have gained with years of experience (Rockwell et al., 2017). How to achieve a shared understanding between teachers and researchers? The direct transfer of successful methodologies across contexts is not advisable. Therefore, sharing experiences from diverse contexts is essential for enriching the literature about building communitarian pedagogies.

Here we share our reflections about knowledge democratisation in a project that aimed to create an educational proposal for communities that struggle with socio-environmental crises. First, we describe the aims and context of the project. Then we outline that knowledge democratisation processes play in constructing new pedagogical knowledge tailored to the needs of communities in

crisis. Finally, we present a brief account of the tensions and insights that emerged in our attempts to build a horizontal collaboration with teachers and how this collaboration impacted our understanding of what communitarian mathematics education might entail. We conclude by explaining how teachers' knowledge impacted our understanding of how to enact a communitarian spirit in mathematics education.

Mathematics education for community and socioenvironmental issues

Here we share part of our experiences conducting the project "Community, Science and Education", which aimed to bridge the voices of community leaders, environmental and health scientists, teachers, and mathematics and science educators to bring education close to the concerns and needs of communities seriously affected by a socio-ecological crisis (Solares-Rojas et al., 2022). In this presentation, we will focus on the communities located in the Atoyac river basin in Tlaxcala state, México. Several studies in this region have reported on the high pollution levels from heavy metals, volatile organic compounds, endocrine disruptors, neurotoxins, mutagens, and carcinogens present in the Atoyac River stream (Arellano-Aguilar et al., 2015). These pollutants in the area are a health risk, particularly for the child population. Physiological, metabolic, and genotoxic damage has been observed in schoolchildren in the industrial area and near the Atoyac river (López-Vargas et al., 2018; Montero-Montoya et al., 2020).

We wanted to make an educational contribution to helping the communities facing this socio-ecological crisis. Our objective was to design a kind of pedagogy that could support the community in using science and mathematics to understand and act on their environmental and social reality. Our intention was in line with researchers such as Skovmose and Valero (2010), who have emphasised the need for engaging in practical projects in which mathematics education can participate in social and political issues. However, there are no specific guidelines for conducting such projects practically. In our case, we decided to address this challenge with a co-construction approach.

Our co-construction approach

Through the school year 2020–2021, we engaged in the co-construction of educational activities with teachers from a rural primary school located in the Atoyac basin. It is a primary school with groups for all elementary school grades, from Grade 1 to Grade 6. About 350 students attend the school, with 14 teachers, one principal and one vice principal. It is relevant to mention that the school has previously collaborated with projects documenting child health impact conducted previously by members of our team. This previous work eased the openness of the school administration about our project.

Teachers, mathematics and science educators, community leaders and environmental and health scientists collaboratively designed educational activities to address specific socio-ecological local issues. We did not aim to transmit scientific information or pre-designed educational activities to teachers so they could use it in their classes. Instead, we sought the co-construction of educational activities addressing specific local environmental problems that were also viable and useful in the actual conditions of the classrooms (Rockwell et al., 2017). These activities are situated in the school's specific context, constraints, possibilities, and the community's socio-ecological issues, history, and fights. In practical terms, the co-construction process involved a series of meetings with teachers. We

organised teams that worked on three strands: Socioenvironmental rights, history, and pollution. The meetings did not follow any script, and we intentionally avoided following any pre-defined theoretical view for working with teachers. Initially, we restrained ourselves from taking an "expert" stance. Instead, we wanted to follow the lead of teachers in order to facilitate a horizontal organisation. In retrospect, we were trying to facilitate conditions for a democratic generation of knowledge.

Knowledge democracy

We use the term knowledge democracy as a construct that can help us to theorise our experiences in developing a communitarian approach to teaching mathematics. Knowledge democracy is an approach to thinking about the production and communication of knowledge as a horizontal process. This approach challenges the idea of status quo "experts" as owners of legitimate knowledge, which implies an "epistemicide" in terms of de Sousa Santos (2018). According to Hall and Tandon (2017, p. 13), the central tenets of knowledge democracy include acknowledging the importance of multiple epistemologies, including the knowledge of marginalised communities. Second, knowledge can be created and represented in multiple forms, including, for example, text, images, numbers, stories, music, or ceremony. Third, knowledge is a powerful tool for participating in social movements and constructing a just and healthy world. And finally, knowledge democracy implies open access to knowledge for everyone.

These ideas are consistent with mathematics education perspectives that emphasise the importance of integrating the knowledge of communities with the mathematics knowledge that students are expected to learn in school. For example, the term "funds of knowledge" coined by González, Moll, and Amanti (2005), refers to the body of knowledge and skills that have been accumulated through cultural processes and that are essential for individual functioning. This term has helped understand that out-of-school is invisible in the mathematics classroom, provoking a discontinuity that primarily affects students from disadvantaged households (Anderson & Gold, 2006). Therefore, by constructing bridges for connecting school mathematics with everyday experiences, students can access rich learning experiences by using the resources and experiences that belong to their communities. To do that, researchers need to engage with a dialogic perspective and establish a two-way dialogue with community members, including, for example, teachers and parents (Civil, 2002b).

We argue that the dialogic perspective necessary to take advantage of communities' funds of knowledge implies a democratic construction of knowledge. This process demands a change of perspective from researchers to make mathematics education with and for the people instead of researching them. Of course, the process of knowledge democratisation is not about denying the merits of academic knowledge. However, the theoretical and methodological tools used in the academic arena must be tuned to engage in dialogical communication with the community. In our experience, we discover that the democratic construction of knowledge can be full of tensions.

A network of tensions

During the development of our project, we intended that the teachers would take ownership of the project and be the main actors while the researchers were only support or guide to implement and extend their strategies. However, the lack of assertive dialogue caused a first rapprochement where

the tension between professors and researchers flourished. Tensions refer to contradictions. Here we describe how these tensions emerged and shaped the new knowledge of our project.

It was impossible for us, trained as researchers in mathematics education, to forget all the knowledge we had accumulated in academia, and questions emerged, how to dialogue with teachers? Do we need a theory? What method? Those were some of the questions we asked ourselves. We thought of building common ground by recovering teachers' knowledge. Our view was that by working on extending activities that they had already used with their students, teachers could design new activities to address an environmental problem of their own. We assumed that this process of building common ground would be straightforward and that the teachers would actively and collaboratively develop the activities. However, we initially faced that they came up with an, apparently, subordinated attitude, asking the "expert" researchers to tell them what and how to carry out the work in their classrooms, which caused great tension among us researchers because teachers violated our initial expectations.

It made us sad to talk with the members of the Network about our first meeting with the teachers. We still remember the feeling after this meeting because it did not turn out as we expected. The teamwork we had thought to carry out with the teachers was not working out. We were afraid to prepare for the following meetings; we wondered if the teachers would return and how we could convince them to continue participating. Along the way, we had to change our plans, and our perception of the teachers also changed in that process.

That the teachers referred to us as "the scientists" is consistent with an internalised image of researchers as owners of institutional knowledge. From the beginning, the teachers asked us to define the actions they would carry out, and they wanted some booklet, information or images to support their teaching. We responded that we intended to build on teachers' experience, needs and motivations and not to prescribe pre-designed didactic solutions without the participation of teachers. Our response triggered an even more insistent reaction from teachers. Almost all gave arguments in the same sense, asking for guidance from "specialists". They argued that we were "turning the tables on them". They emphasised that the specialists that had investigated the problem of the river envisioned the project and reached out to them. It was their obligation to give them guidelines. However, the teachers said that the researchers would not support their initiatives. Instead, they were going to "land" the initiative of the researchers in the classroom. They argued that, although they had experienced the transformations of the river, the "experts" had more information.

The other "owner" of knowledge is the curriculum. For teachers, the curriculum dictates what students should learn and how. The arguments established in the curriculum are unalterable. Teachers made us aware of a striking difficulty. The mandatory Natural Science books present content such as the parts of the body or other environmental phenomena, but the Atoyac River pollution was not present.

We learned to value teachers' knowledge beyond the discourse, but in practice and in a way that impacted our points of view. We allowed ourselves to dialogue with the teachers to find out their concerns, doubts and proposals to carry out the activities that would allow us to achieve the purposes of both the project and each one of the teachers and begin to weave the curriculum. In particular, we

stopped interpreting that they were resisting. We realised their doubts came from a deep commitment to teaching and the community.

The outcome

Our way of weaving the curriculum with the teachers changed over time. In September 2020, before meeting with the teachers, we thought a "Historical Reconstruction of the River and the Community" could be orchestrated in the classrooms. The idea was for the students to do interviews and collect historical material such as stories, maps, and photographs. In January 2021, we developed this idea to integrate the topics we wanted to address with the official curriculum. We looked for a way to establish correspondence between the different activities we were asking teachers to do and the contents of the study plan for each grade. The proposal was for the teacher and the students to analyse the collected material using dimensions such as time, activities, places, feelings, and characters. Despite our intentions, our proposal maintained a marked academic essence, focused on generating knowledge and understanding of the phenomenon from formal analysis. This approach was not helping us to co-construct a communitarian pedagogy with teachers.

It was not until April 2021 that we established common ground with teachers. We wanted to consider the reality of the room, and we were talking about ideas like mainstreaming as a possibility to integrate network activities with the curriculum. It was a difficult challenge. For example, we could never integrate the activities related to the history of the Atoyac River with a specific mathematics topic. However, the teachers taught us how to work transversally with other subjects.

Concluding remarks

Our ideas of a communitarian pedagogy had to be landed in the classroom to become real. The classroom was an optimal scenario for meeting with teachers and other academics. It was the place to engage with a democratic approach to constructing knowledge. The classroom helped us blur the boundaries of knowledge ownership and created knowledge democracy with co-construction. The co-construction approach oriented the dialogue with teachers. In the end, we managed to build communication channels that supported the construction of new activities in an environment of trust and mutual understanding.

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