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Board 185: Work in Progress: Engaging Students in the UN Sustainable Development Goals through Funds of Knowledge: A Middle School Bilingual Classroom Case Study

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Introduction

In response to the different challenges that humanity faces, the United Nations Educational Scientific, and Cultural Organization [1] has proposed 17 goals that seek to unite us as a community for the good of people, the planet, and for prosperity. Each of the goals are fundamental to achieve the objective of reducing injustice and poverty. Within these goals in mind, one issue that is relevant for teachers and students to talk about – particularly after the COVID-19 pandemic – is to "ensure healthy lives and promote well-being for all at all ages" [1, p. 16]. COVID-19 generated a high number of deaths worldwide, but it also exacerbated disparities between privileged and minoritized groups. For example, in the United States, the number of Latino deaths was around 28.3% of the population – mainly due to living in densely populated areas and having limited access to resources and information in Spanish that would have allowed them to take preventive measures [2]. In other words, the information provided for awareness did not consider the context of the Latino community. Therefore, it is important to not only present the challenges but also problematize, from an early age, the complexity of these challenges and recognize that impacting factors cannot be isolated.

As indicated by the National Academies of Sciences, Engineering, and Medicine [3], addressing these complex challenges requires interdisciplinary actions. This paper, is part of a larger study exploring the enactment of Funds of knowledge (FoK) to gauge participation of students and teachers in engineering. The objective of this work in progress paper is to present our findings around a case study of a seventh (bilingual) and eighth-grade mathematics teacher who focused on adapting and building activities for her transfronterize –individuals that navigate the United States and Mexico borderlands– students. The activities centered on an interdisciplinary approach that draws from mathematics, engineering, and FoK to help students deepen their understanding of mathematics and engineering while raising awareness of well-being. The research questions that guided this case study were: (1) To what extent does FoK-based professional development contribute to a teacher's (re)conceptualization of mathematics education activities in the classroom to expand students' perceptions of engineering? and (2) To what extent does the teacher's creation of these activities provide middle school students with opportunities to reflect on their physical and mental well-being?

Conceptual Framework

Funds of Knowledge. The concept of funds of knowledge emerged from the work of Velez-Ibañez and Greenberg [4] who described the strategic and cultural resources and skills utilized by Mexican American families in the U.S. Southwest. They described how these "specific strategic bodies of information" [4, p. 314], were utilized to ensure and maintain the well-being of their families. For instance, they described families and their knowledge of folk medicine to provide medical care for their families due to the lack of doctors and the discrimination faced by Mexican Americans in rural areas in the Southwest. Eventually, Moll and colleagues [5] used the work of Velez-Ibañez and Greenberg as the basis for their ethnographic studies to document the funds of knowledge among Mexican American families and children in the Southwest. The goal was to allow teachers to better understand their students while challenging their own deficit ideologies. The recognition of funds of knowledge in the

household and community allowed teachers to think about empowering pedagogies that would position students' lived experience front and center in the curriculum.

The work on funds of knowledge has been extensive since the time it was applied to educational contexts by Moll and colleagues. These studies have explored the potential for funds of knowledge to serve as a bridge between science, scientific literacy, and everyday experiences [6-7] mathematics and community knowledge in the form of funds of knowledge [8], and as a way to describe everyday knowledge with engineering practices [9-10]. Thus, funds of knowledge serves as both a theoretical and pedagogical counter discourse to deficit-based models and pedagogies where individuals' lived realities are often disregarded as valid in the process of knowledge construction [11-12] in STEM.

STEM integration through engineering design. According to Committee on STEM Education, "the best STEM education provides an interdisciplinary approach to learning, where rigorous academic concepts are coupled with real-world applications and students use STEM in contexts that make connections between school, community, work, and the wider world" [13, p. 1]. Training students under an integrated approach can make teaching more relevant to students and teachers [14]. A fundamental issue in STEM is the consideration of the mechanisms that promote the integration of disciplines [15]. "STEM integration learning environments should require students to use critical thinking and problem-solving skills to work across the disciplines" [16, p. 3]. These skills can be addressed by students through design [17]. Integration based on engineering design allows students to delve into disciplines such as science and mathematics [18]. In addition, Fan and Yu [19] have shown that students enhance their disciplinary knowledge and analytical skills by engaging in STEM activities integrated with engineering design. "A particular feature of STEM integration through design is the range of learning opportunities afforded throughout problem solution. Learning while designing is thus a key contribution of design-based problem solving" [17, p. 51].

Methodology

This qualitative case study involved a female, bilingual, transfronteriza seventh-(bilingual) and eighth-grade math teacher recruited to participate in a larger study where middle school teachers were asked to collaborate with a group of researchers to integrate engineering and FoK into their curriculum at a STEM-focused, Title I, middle school near the U.S. - Mexico border. The data collected for the analysis described this paper came from the researchers' detailed review of interviews, audio transcripts of the interviews, and researcher's field notes during the implementation of the teacher's activities. Since we were interested in knowing the teacher's interpretations during different parts of the process of adaptation and construction of the activities, we conducted a single-case in the rationale of the longitudinal case [20]. A deductive approach was used following a "*relying on theoretical propositions"* analysis [20]. The data presented here comes from direct interactions between Dr. Mejia and the teacher, Ms. Robles, as they discussed how to develop the "road signs" and "healthcare" activities.

The first coding cycle focused on opportunities the teacher employed to elicit students' FoK. Since we were interested in recording the teacher's process of constructing activities, we had special interest in the FoK approach as "an educational intervention aimed at transforming teaching activities by connecting school curricula to the Funds of Knowledge of their students" [21, p. 572]. The second cycle focused on the identification of opportunities by the teacher to use design as a form of integration in STEM and engineering. The data was analyzed using NVivo 12 software, which allowed for the analysis and subsequent combination of codes into three main categories. Preliminary results indicate that the activities proposed by the teacher generated three different pedagogical opportunities for the students: *opportunities to elicit FoK*

(O-FoK), opportunities to deepen STEM concepts (O-STEM), and opportunities to deepen engineering skills (O-Engineering).

Preliminary Results

In this section, we report the preliminary results, which are organized into four different stages to show the progression of the teacher's conceptualization, analysis, and implementation of FoK in her class activities. The first two stages describe how the teacher adapted an activity originally proposed by the school district on the mathematical concept of geometric figures while figuring out how to integrate FoK and engineering. Stages 3 and 4 describe the teacher's development of an activity where the mathematical concept was scatter plots. The stages are representative of the impact of the collaboration between the research team and the teacher, and the changes occurred throughout the study where the teacher started to develop an initiative and (re)conceptualization of mathematics education, engineering and FoK. It is important to mention that what is described next occurred during the COVID-19 pandemic and most of the implementations were done online.

Stage 1. Here, we describe the first stage of adaptation of the "Road signs activity." The original activity suggested that students analyzed photos and videos of road signs, and later discuss the geometric figures of the structures of the road signs. After a series of professional development workshops and discussions with the researcher (Dr. Mejia), the teacher adapted this activity for her students. The initial ideas of eliciting students' FoK were proposed by the researcher. The teacher tried to connect the ideas of FoK in the activity, but she was confused between the concepts of FoK, prior knowledge and engineering design process. Initially it was hard for her to think about how FoK could be elicited in the classroom (i.e., [O-FoK]):

> [Dr. Mejia]: For the FoK part, [students] can start asking questions at home. Either they discuss the issue with their parents, or they make the same observation at home.
>
> [Ms. Robles]: But for the FoK would be the design process? What do they do know about the design process?

The teacher's initial ideas focused on mathematical concepts associated with her curriculum and her district directives, particularly thinking about geometric shapes [O-STEM]. The opportunities to deepen engineering skills [O-Engineering] ideas were initially suggested by the researcher. Nonetheless, the teacher also suggested that part of the activity could include asking the students about the design process used to build the traffic signs they see in videos or photos – realizing that an inquiry process is necessary to elicit funds of knowledge:

> [Dr. Mejia]: But [the students have to] identify the problem. The problem in reality is to build a structure that can hold the road sign.
>
> [Ms. Robles]: [I could] ask them what do they do know about the design process and the roads signs support and [have them] ask their parents.

Stage 2. Second stage involves the adaptation of the "road signs activity." The interaction with the researcher allowed the teacher to reflect on how to elicit students' FoK. The teacher proposed including videos of road signs but have the students identify which types of road signs they had seen when they travel with their parents, and ask their parents what is the meaning and importance of road signs for safety. The teacher proposed translating the slides into Spanish for the bilingual students. In addition, after a reflection about engineering, she proposed that the students should build the road sign with materials they had in their houses [O-FoK]:

> [Dr. Mejia]: When the students are doing brainstorming, think about FoK; they could ask their parents.
>
> [Ms. Robles]: Ask their parents, what is the meaning or the importance of the road signs? how does this affect the safety? Also, I have to translate [Spanish] for my bilingual class.

The teacher also identified in the context of the activity connections between the STEM disciplines of mathematics and engineering. She proposed that the students identify the different geometric shapes in road signs and how these geometric shapes, especially the triangle –something she learned through a video–, were essential in engineering design [O-STEM].
In addition, the teacher proposed that the students build their road sign; however, the materials were a limitation (because the classes were online). But she suggested that the students could use materials they have at home. She also thought that the students would consider the engineering design, taking into account the constraints and the engineering tool kit the researchers developed for the teachers [O-Engineering]:

> [Ms. Robles]: [I could] let them build their road sign with wire, straws, also with chopsticks. I want to use the topic of the constraints and the engineering design process tool kit. I wanted to use it so that they were doing the steps of the Engineering Design Process.

After the first and second stages, the teacher was able to adapt the road signs activity, expanding the opportunities for the students (i.e., *O-FoK, O-STEM, and O-Engineering*). The teacher expanded her knowledge of FoK, engineering design, and STEM through this iterative process of creation and implementation.

Stage 3. Here we describe the first time the teacher developed the "health care" activity. After adapting and implementing the road signs activity for her students, the teacher designed an activity from scratch based on the mathematical concept of scatter plots. From the beginning, the teacher found it relevant to build an activity in a context close to the students and their families. With this in mind, the teacher proposed the context of the spread of COVID-19 in the community, the effect of obesity, and the impact of the number of hours of sleep of the students. She described these opportunities to analyze data in scatter plots as follows [O-FoK]:

> [Ms. Robles]: To make it more explicit [and close] for the students, they can compare the factors, such as population versus COVID. Also, people who were obese were more likely to have COVID. […]. And also, now that we return to face-to-face, I see them tired and I see them not very energetic, so yes, also the hours of sleep.

The teacher sought to build an activity based on a real, close and relevant context for the students where they had the opportunity to delve into mathematical concepts. These aspects in the context of an activity are essential for integration in STEM [17]. The teacher wanted students to have the opportunity to interpret graphs, identify variables and covariation of variables [O-STEM]:

> [Ms. Robles]: Students could comment how the variables affect or influence the graph. For example, if I am comparing people who have more BMI (body mass index) and those who were infected, what kind of graph am I going to see there?

In addition, the teacher was interested in including engineering but did not have a clear idea of how to integrate it. The researcher proposed to the teacher to think about engineering design from the aspect of analysis and approach to the situation (i.e., how to use this information in engineering decision-making). The teacher proposed that, regarding the data and graphs of the activity, the students discuss the question: How can Engineers use this data and why they should analyze it? The researcher reinforced this idea by helping the teacher create a structured questioning for the students [O-Engineering]:

> [Dr. Mejia]: Start doing the analysis, and to connect with engineering, how does this help us, this data and this analysis, how does it help us to formulate a problem and be able to solve it?

Stage 4. We describe the second stage of construction of the "health care" activity. After implementing the activity with her students, the teacher modified the activity for her next

semester. The researcher asked the teacher if, in order to elicit the students' FoK, she would consider having the students bring their own data for analysis. Based on this reflection, the teacher proposed to modify the activity so that the students recorded their data to analyze what they eat every day at home and at school, the calories in these foods, and the number of hours they sleep per day. Together with the researcher, the teacher created a Google Sheet that would automatically record the number of calories consumed based on a list of food offered by the cafeteria during the month. Since most students received free or reduced lunch at school, she saw the opportunity to collect data from information that was already available for students [O-FoK]. The students recorded their information using Google Forms on a daily basis using the Google Sheet with pre-determined foods. With the information collected, students had the opportunity to build tables, identify and associate variables in different mathematical representations (e.g., verbal, tabular, and graphical), discuss variable association, and create scatter plots. She gave the students the opportunity to discuss aspects of science related to the activity, and she emphasized the importance of students reflecting on their health care [O-STEM].

> [Ms. Robles]: I need them to start paying more attention to what they eat at school and at home and how much they sleep. They will fill their tables with their data and we will build graphs.

The teacher saw this as an opportunity to increase the students' awareness of health and well-being through mathematics. The teacher created the modifications to the activity so that the students could delve into the analysis of data connected to engineering by having students answer the question: How can engineers use this data and why should they analyze it? [O-Engineering]. The teacher built an activity in which the students –based on their daily eating data and hours of sleep – built tables, discussed the effects of calorie consumption, reflected on the effects on their health, and delved into aspects of mathematics, sciences and engineering.

Discussion and Future Work

In response to the first research question, the analysis allows us to conclude that the teacher created activities that could give students the opportunity to make integrated connections between FoK, mathematics, and engineering. She proposed that the students bring their FoK to the classroom by relating the design of the road signs they found on their family trips and analyzing with their families the importance of safety. She expanded O-Engineering because she proposed that they should go beyond just watching videos to building their road signs with materials from their homes and referencing practices that were familiar to them. This opportunities converge with the STEM integration through design approach [17], because the students, while engaging in designing the road signs, can discuss the constraints, the problems that arise from the design, their findings, and use their knowledge of mathematics to support their designs. In addition, they discuss the role of engineers in problem framing.

Regarding the second research question, the teacher built an activity in which the students, based on their daily eating data and hours of sleep, built tables, discussed the effects of calorie consumption and reflected on their effects on health. They also delved into aspects of math, science, and engineering. As can be seen, it was a series of questions from the researcher about expanding the FoK connection opportunities that prompted the teacher to develop her activity in different directions. The teacher modified her activity, which gave students more opportunities to deepen their mathematical ideas and skills, make their FoK more relevant, reflect deeply on their health care, and critically analyze the role of engineering and data analysis and interpretation. Future research and extension of this work will describe the impact of the activity on the students, and analyze the teacher's perceptions on FoK and engineering.

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