International collaboration powers teachers' STEM learning

BY LINDA ROST, MELISSA OLSON, SHAZIA IQBAL, ROBYN EMBRY, AND WALTER SMITH

Teachers are uniquely situated to enact best practices for the direct benefit of student learning. However, teachers often lack opportunities to exercise agency, the capacity to "make an impact or exert power" (Gourd, 2015, p. 12). When teachers develop agency, they are better able to implement place-based, relevant lessons for their students.

Developing agency was one of the primary goals of an international project we led to explore how to bridge the gap between the ways teachers in different cultures and countries teach STEM — science, technology, engineering, and mathematics. In this global collaboration, American and Pakistani educators worked together to implement teacher-centered professional learning about how to design lessons and curriculum that are standards-based, contextualized, and engaging for their students.

We created a cooperative community of professionals in which teachers from different cultures could learn from one another, developing agency and improving practice to make STEM relevant and applicable to their students.

This project took place over a four-month period in spring 2021 in the United States and Pakistan. It was led by three American classroom teachers (Robyn Embry, a high school teacher in Indiana; Melissa Olson, a high school science teacher in Minnesota; and Linda Rost, a high school science teacher in Montana), and an international educator (Shazia

Iqbal, from Pakistan and Texas). We conducted the project as part of a global STEM course at Texas Tech University, where we are all doctoral students, under the mentorship of professor Walter Smith.

The project was divided into four phases. In the first phase, we, the American and international teachers, explored the professional learning needs of Pakistani teachers in a private school nestled in a rural village of Punjab. Next, we conducted online professional learning in the form of an "unconference" (or teacher-driven session where teachers teach each other) to address their needs.

In the third phase, the Pakistani teachers incorporated the strategies and tools they learned to facilitate STEM-based student projects linked to the local community, and then they shared their projects, teaching us. Finally, in the fourth phase, the Pakistani teachers created similar professional development for other teachers at their school.

PHASE 1: MEET AND GREET

We organized a meet-and-greet via web conference to introduce ourselves and get to know the Pakistani teachers with whom we would be collaborating. This step is vital for strengthening relationships, developing trust, and listening to the needs of the teachers and what they would like to gain from this experience to enhance student learning.

The online meet-and-greet began with us introducing ourselves, providing our background experience, and reviewing the overall goals of the project. We stressed a two-way street of professional development in which everyone would be sharing and learning from each other, rather than one group teaching the other. Then Pakistani teachers introduced themselves and shared their ideas and thoughts about the professional development.

Next, we moved into four breakout rooms, at which point we introduced the instructional technology of using Google Jamboards. In the breakout rooms, teachers answered questions using Jamboard's sticky note feature. The discussion questions focused on identifying an area of pedagogy on which they would like to work and local STEM topics they would like to highlight. They also examined the United Nations' Sustainable Development Goals and explored which ones could be incorporated into their students' STEM projects.

The United Nations General Assembly adopted the 17 goals (see below) in 2015 as a core component of its 2030 Agenda for Sustainable Development. The aim of the goals is to direct humanity toward sustainable economic growth by addressing global economic, environmental, and social issues and to "secure a sustainable, peaceful, prosperous and equitable life on earth for everyone now and in the future" (UNESCO, 2017, p. 11). We believe in the importance of incorporating these goals into student projects so that students learn about real-world issues, solutions, and impact.

UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS
(UNESCO, 2017)

PHASE 2: UNCONFERENCE

To prepare for the unconference meeting, an open format conference where individuals share and participants can move freely between sessions, we debriefed about the topics addressed in the breakout rooms during the introductory session. In addition, Shazia Iqbal, who was living in Pakistan, traveled to the school in Punjab to meet with the teachers in person and tour their classrooms.

This face-to-face meeting allowed her to explain the collaboration in greater detail without the barrier of technology and the internet. As Iqbal guided them in cross-curriculum mapping, the Pakistani teachers formed groups based on their subject-specific learning objectives and interests, aligning the United Nations goals to each of their topics.

Through this process, we learned that teachers wanted to learn more about instructional technologies. The Pakistani teachers said that they had many professional development opportunities focused on specific content knowledge but limited opportunities to learn innovative strategies to teach online. The onset of the COVID-19 pandemic made it imperative that teachers keep students engaged with online instructional technology.

Since the majority of reputable schools in Pakistan are privately owned with the emphasis placed on profits, technology equipment is not always provided, and, if the equipment is present, the teachers are not trained to use it. Fortunately, this school did have the equipment and the support of the administration to incorporate the strategies within their lessons.

The teachers were eager to enhance their competency, and they planned to build their online instructional proficiency to keep the learning process ongoing during forced school closures due to the pandemic.

Once we had organized the unconference, we shared a one-page flyer with details so the teachers would know what to expect. We intended this unconference to introduce instructional technologies that the Pakistani teachers could use for online, hybrid, and in-person teaching. We devised a "sandbox" time for teachers to move through various breakout rooms and explore the different technologies and discuss ways to use them in their classrooms.

During the conference, our leadership team facilitated discussions and shared information. Melissa Olson explained how she used Google Classroom to facilitate communication, lead asynchronous discussions, provide comprehensive feedback, and assessment.

Robyn Embry described how she used Google Slides to create digital interactive notebooks, in which students can move through prepared slides and interact with the main topics through activities such as posting selfies and captions to demonstrate different concepts, importing photos or diagrams, creating comic strips, and matching text boxes and diagrams with topics.

Linda Rost explained how she used Google Slides to design experiments, collect data, create graphs, and assign essays with directions and rubric embedded in the template. She demonstrated using Google Slides for group projects and Jamboards for critical annotated reading, using the highlighter and sticky note features.

After the sandbox time, Rost shared how she uses pinwheel discussions to teach about controversial or provocative topics in science. Specifically, she used these interactive conversations to provide a culturally responsive lens to four place-based topics: managing and delisting the grizzly bear in the Greater Yellowstone Ecosystem, climate change with cultural perspective, the introduction of invasive species in Flathead Lake in Montana, and using genetic testing for tribal enrollment. These lessons involve the intersection of Indigenous ways of knowing and Western science. In each of the four units, students explore and analyze data, then collaborate on conclusions.

Finally, the American and Pakistani teachers moved into breakout rooms based on four timely and engaging topics they had identified from their own local context: salt mines, climate change, industry and energy, and agriculture. After the in-person meeting in Pakistan with Iqbal, teachers had already formed some ideas about the lessons they planned to develop for their students.

Now, during the unconference, they explained how they planned to incorporate one of the United Nations goals and an instructional technology within their lesson. They summarized their ideas on Google slide templates to reinforce the technology skills they were learning.

Following the breakout rooms, we reviewed how the Pakistani teachers would be presenting the results of their lessons at the next meeting.

PHASE 3: SHARE

The final meeting for this collaboration involved the Pakistani teachers showcasing their work. Each of the four groups gave presentations on the collaborative units they had designed with their colleagues and how their students engaged in the content.

The units aligned with their curriculum and included one of the United Nations goals, a new instructional technology, and a new teaching method. Some of the collaborations included science, math, computer science, and English language teachers working together on the same unit.

Following each presentation, the other team members asked questions and provided feedback for each group. At the end of the meeting, the group collaborated on a Google Jamboard to share the main takeaways from the collaboration.

This phase demonstrated the value of the two-way street approach to collaboration. The teachers learned from each other and we, the leaders, also learned things we can use in our own classrooms. We found that the

Pakistani teachers were already using sustainability goals in their curriculum and recognized our own deficiency in this area.

In addition, the Pakistani teachers used many techniques to initiate discussion with their students with which we had little or no experience and provided models for how we might teach about science topics in our own classrooms. For example, a chemistry teacher who used the local salt mine crystals as a phenomenon to explore the rate of crystal growth in the lab sparked ideas for how we could use similar local phenomena in our own classrooms.

PHASE 4: TEACHING OTHERS

Finally, the Pakistani teachers took what they learned and created professional learning for other teachers in their school who did not take part in the initial program. This collaboration started a chain of sharing that moved down grade levels, providing many teachers with professional learning as well as a rare opportunity for teachers to share their knowledge with others, which facilitates teacher agency.

WHAT WE'VE LEARNED

Teachers' feedback and the depth of their final products suggested that the project was successful in reaching its goal of establishing a collaborative community, building knowledge, and building teacher agency so that teachers can apply their knowledge of local context to teach STEM in ways that are engaging, relevant, and applicable for students.

During our follow-up discussions and debriefing meeting, we, the leadership team, identified several possible factors in the success of the project. First, we honored the needs, desires, and knowledge of the teachers. Often with professional learning, there is a top-down decision of need. This was particularly a risk in this project because we entered into the professional collaboration with little knowledge of the current working of the school and country.

Though we came from two different countries, we were all able to understand and relate to one another.

We could have slipped in trying to "fix" a school in a country that is vastly different from our own, but we knew it was crucial that we honor the prior success of the Pakistani teachers and assist them in growing in areas that they were passionate about, while we ourselves were also growing.

Second, we emphasized the relationship of the curriculum to the local environment, culture, and economy because learning can be more powerful and effective if it connects to prior knowledge and real-life experiences (Bretz, 2001). Having teachers incorporate a local phenomenon into lessons not only makes lessons more engaging for students but also creates connections between school and community.

By focusing on the local salt mines, agriculture, industry, and climate change, the teachers began to see their curriculum in a new light. Though the local environment can create constraints to teacher agency (Gourd, 2015), it can also create opportunities for teachers to be agents of change in the community.

Third, administrators' support for the Pakistani teachers to participate in this professional learning was important. The support from multiple levels — from the owner of the school to the lead teachers — allowed teachers to take agency in improving instruction in their classrooms and also provided structure to enable that agency.

Fourth, although administrative support was important, the fact that the project was created by teachers for teachers was powerful. Since we also experienced teaching online and have worked to incorporate local phenomena in our own teaching, we empathized to some extent with the realities of the Pakistanis' situation. Though we came from two different countries, we were all able to understand and relate to one another.

Finally, the tools and guidance we all shared were highly valuable. As past experiences with teacher self-directed professional learning show (Rose, 2020), teachers greatly appreciate an opportunity to exercise their agency, but having guidelines in place is important for efficient use of the professional development time.

Throughout our project, the teachers had many opportunities to make choices, use creativity, and explore interests; yet there were clear expectations for the outcomes. The clear expectations throughout the project furnished teachers with opportunities to act within the constraints provided and also maintained the structure to enable agency by affording opportunities and resources to improve (Gourd, 2015).

How the teachers used the resources presented during the lesson was up to them, but they needed to try at least one new pedagogy and one new instructional technology when instructing about a local phenomenon.

FINAL THOUGHTS

This professional learning collaboration was as valuable a learning experience for us as it was for the Pakistani teachers. It illustrates the benefits of intercultural collaboration for everyone involved and inspires us to continue such collaborations.

There are many ways collaboration on the current project could continue. For example, the teachers and students in Pakistan and the U.S. could continue to communicate to compare how each group contextualizes its learning within its environment and community.

In addition, we are pursuing other collaborations. Iqbal is working with the University of Chakwal to develop a pilot for an educational partnership with the Engineering Projects in Community Service department at Purdue University.

The EPICS projects will promote STEM learning and contextualization

Continued on p. 62

responsive pedagogy (Gay, 2018), and culturally sustaining pedagogies (Paris & Alim, 2012) matter to the success of minoritized students. But they cannot be adopted and enacted without critical exploration of self, context, and systems of racism, classism, sexism, xenophobia, homophobia, and transphobia that permeate our educational landscape.

The cultural inquiry process is one way to engage educators' learning in ways that prime them to notice the cultural influences on inequities, reflect on their existence and maintenance, and act in ways that can address the conditions of inequity inside their classrooms and beyond. It must be noted that, while powerful, any inquiry process cannot be the only means of systemic change. However, because of teachers' direct connection to students, teacher learning through cultural inquiry is a vital component of equity efforts in education.

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International collaboration powers teachers' STEM learning

Continued from p. 57

for students before joining the university and encourage students to enter the engineering field as they gain experience in seeking solutions to real-world problems and enhancing their quality of life.

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