Research-Community Partnerships to Support Teacher Professional Learning

by Katherine Wade-Jaimes, University of Nevada Las Vegas; Rachel Askew, Freed-Hardeman University; Cullen Johnson, Memphis Teacher Residencey; & Chuck Butler, Memphis Teacher Residency

Abstract

Providing ongoing support for inservice teachers is a challenge faced by school districts, educational organizations, and colleges of education everywhere. In this article, we describe a partnership between a community-based educational organization and educational researchers designed to provide professional development and support for science and math teachers while also supporting youth participating in a summer STEM program. Originating from an identified need of the community organization to better support youth STEM identity in their programming and rooted in a framework of STEM identity and equity in STEM, this partnership leveraged resources from different groups and was shown to be beneficial to the community organization, educational researchers, teachers, and youth. It this article, we discuss the logistics of this partnership and how it was implemented during a summer program, provide outcomes from youth and teachers, and include suggestions for the development of similar partnerships.

Developing Research-Community Partnerships

Although educational researchers in traditional university settings typically have many opportunities to work with preservice teachers, developing ways to support inservice teachers is more challenging but just as important. Partnering with community organizations that have existing relationships with inservice teachers, schools, and students can help facilitate this because many education-focused organizations have developed networks of teachers through their existing programming. In this article, we demonstrate how fruitful research-to-practice partnerships can be for all involved, enabling various groups to leverage existing resources and relationships in support of teachers and students in science, technology, engineering, and math (STEM). We also show how existing youth programming can be used creatively in these partnerships in support of teacher professional development.

A research-to-practice partnership is a partnership between an educational organization, such as a school or district, and researchers that is designed to address specific problems of practice (Coburn & Penuel, 2016). They are meant to be long-term and mutualistic, meaning that authority is shared between partners (Coburn et al., 2021), with a similar philosophy to professional development schools in which educational knowledge is shared between all interested partners in an educational community (Darling-Hammond, 1994). In science

education, research-to-practice partnerships have been shown to be successful in supporting equitable science instruction (Penuel, 2017). In this article, we describe a collaboration between a teacher-preparation-based community organization and a group of STEM education researchers. Originating in the needs of the community organization, this collaboration allowed both groups to work together to support shared goals of equity in STEM by providing social-justice-focused professional development for inservice teachers. By working together, the groups were able to coordinate the professional development with existing STEM programming for local students, leading to more meaningful experiences for both students participating in the programming as well as teachers participating in the professional development. This benefited both the community organization, which was able to provide high-quality and focused professional development to their participating teachers, and the researchers, who were able to study the impact of the professional development with a group of enthusiastic teachers. Here we describe how this collaboration was initiated and provide details for one specific component of the collaboration, a summer professional development institute for teachers that was held concurrently with a summer STEM camp (run by the community organization) for local youth. We present a framework for this partnership, a description of program components, and data to demonstrate the effectiveness of this work. Finally, we discuss challenges, next steps, and strategies for implementation.

Origin of Partnership

The research-to-practice partnership described in this article originated organically in a specific need from a community teacher preparation organization. This section details how that need was identified as well as how connections were made to researchers who could help address that need.

Memphis Teacher Residency (MTR) is a nonprofit organization focused on teacher preparation. MTR's programming is based on a residency model with an explicit focus on social justice through education. MTR's mission is based on the understanding that "Educational inequality is one of the greatest social justice and civil rights issues in America today" (https://memphistr.org/), and they strategically recruit teachers who are interested in working toward educational justice. In this model, teachers spend one year working with a more experienced teacher in their classroom while also taking classes to earn a graduate degree and teaching certificate. In addition to teacher preparation, MTR has also developed community programs to support educational equity in Memphis and to serve as a recruiting pipeline for future educators. One of these programs is a 3-week summer STEM program that focuses on math integration in STEM. The program primarily serves rising seventh-grade students who are experiencing poverty or come from underrepresented and marginalized communities. At this camp, campers are exposed to mathematical and scientific concepts outside of the typical K–12 curriculum. By exposing students to advanced

mathematical concepts typically reserved for college, the STEM Camp hopes to expand the students' definition of STEM, purposefully foster a sense of achievement in math as it relates to STEM, and improve their perceptions of themselves in STEM.

Due to the Covid-19 pandemic, the first year of the STEM Camp was virtual and abbreviated. Students took three classes over 5 weeks, including topics such as programming, problem-solving, fractions, and challenge problems. The primary goal of the STEM Camp was that campers would grow in their problem-solving skills, their understanding of mathematics as a discipline and its integration in STEM, and their identities in STEM, particularly as mathematicians in STEM. Unfortunately, students at the camp did not make significant gains in their understanding of what STEM is or in their identities with respect to math or STEM.

With the data from the first year of camp, MTR recognized a need to learn more about what it means to identify as a mathematician or scientist and what experiences are needed in order to grow in your STEM identity. As a result, MTR began contacting experts in the field as it pertains to STEM identity for advice and direction on next steps to be taken to cultivate STEM identity in camp participants. Through this process, MTR was able to connect with the first and second authors. This birthed ongoing conversations on strategic ways to support students' STEM identities at MTR STEM Camp and, long-term, throughout classrooms in Memphis. Through these conversations, a research-to-practice model developed. Representing the practice side of the model, MTR wanted to learn how better to support their teachers in learning how to foster STEM identity in students, and the STEM education researchers (the first and second authors) wanted to learn more about effective professional development focused on STEM identity. As a result, several action steps were generated and taken: the creation of a week-long iSTEM Institute for inservice teachers in which participants were able to apply their learnings at MTR STEM Camp, training of camp teachers on strategies to cultivate STEM identity in their camp classes, and concrete recommendations for the STEM Camp Director to take to infuse STEM identity throughout the DNA of the camp experience. Throughout the fall and spring, ongoing collaboration occurred in order to build and develop these action steps. The focus of this article is on the 1-week overlap of the STEM Camp for students and the iSTEM Summer Institute for teachers.

Framework for Supporting Student and Teacher Identity

Because supporting STEM identity was an overlapping desire of MTR and the STEM education researchers, we used a framework of identity development, including the ways in which STEM identities intersect with other identities such as gender and race (Carlone & Johnson, 2007), for this collaboration and, specifically, for developing the summer programming. This framework allowed us to connect the social justice focus of MTR with the identity of students and teachers, which we view as interconnected. Working to explicitly support the STEM identities of students from groups that have been historically (and currently) marginalized from science is an act of social justice, and by engaging in this act,

teachers can develop integrated identities as social-justice STEM teachers. In this framework, identity includes two interrelated components: performance and recognition (Gee, 2000). In order to develop an identity, an individual must *perform* that identity by engaging in behaviors (e.g., actions, thoughts, and language) that are indicative of that identity and must also be *recognized* by others as demonstrating that identity. When considering science (or STEM) identity, Carlone and Johnson (2007) added the component of *competence*, or feeling that you are capable of success. However, research has shown how the culture of STEM (and the stereotypes associated with it) limits who can see themselves as a STEM person (Brown, 2004; Emdin, 2010), leading to the systemic exclusion of certain groups, including people of color and women, from STEM fields. Previous research has also shown that the actions of teachers directly impact students' ability to see themselves as science or STEM people (Archer et al., 2017; Calabrese Barton & Tan, 2009; Carlone et al., 2014).

We also consider it important to understand the ways in which teachers develop science or STEM teaching identities and make decisions in classrooms, as well as how these identities are fluid and intersect with other identities, such as that of a social justice educator (Avraamidou, 2014; Mensah, 2016). Like students, teachers need to be able to both perform and gain recognition for identities, but this process is often constrained. In particular, science teachers are often faced with traditional approaches to science teaching in schools and have to negotiate and find ways to maintain their own views of "good science teaching" with what is supported in their schools (Braaten, 2019, p. 77). Structural constraints also impact teachers' ability to teach science, such as lack of time and resources (Bradbury & Wilson, 2020), indicating that constraints on teachers and on teachers' science teaching identities can in turn impact students' science identity development.

Finally, the research on social justice teacher identities has highlighted a lack of explicit support and models, particularly in STEM (Chen & Mensah, 2022; Moore, 2008). To understand identity development of both youth and teachers and support more robust and equitable identity development for both groups, we argue that the cyclical relationship between student and teacher identity must be considered. Because of this focus on the relationship between student and teacher identity development, the collaboration described here was developed to embed interaction between groups in the professional development and STEM Camp settings.

Description of Programming

The MTR STEM Camp occurred during the summer. The iSTEM Summer Institute was strategically planned for the second week of STEM Camp in order to allow campers and camp staff a week to establish camp routines and norms before partnering with the Summer Institute teachers. Both the STEM Camp and Summer Institute took place in a mixed-use development building that housed the MTR offices (where the summer institute occurred) as well as a high school (where the STEM Camp occurred). The STEM Camp and iSTEM

Summer Institute were designed to overlap in ways that support STEM identity for both teachers and campers. This intentional design allowed teachers to develop practical applications of the theoretical concepts around identity that they were learning during the summer institute and allowed summer campers a chance to provide feedback to teachers and experience identity-focused activities during camp. In other words, this 1-week overlap of the STEM Camp and the iSTEM Summer Institute was designed to explicitly connect research and practice within this partnership.

MTR STEM Camp

In this research-to-practice partnership, the MTR STEM Camp provided the primary "practice" opportunity. The STEM Camp staff included seven camp teachers, one camp coordinator, and one intern. Forty campers (students from local middle schools) participated in the camp; 75% of campers were classified as moderate or lower income, and 100% of campers were students of color. In recruitment efforts for STEM campers, MTR prioritized recruitment in schools in MTR's strategic-partner neighborhoods. These neighborhoods have been identified by MTR to focus teacher placement on increasing high-potential, residency-trained teachers for students at underresourced schools in these neighborhoods. Although there was an admissions challenge for interested campers, all applicants were accepted for the camp.

The STEM Camp met for 3 weeks during the summer. During Monday–Thursday, students took three classes designed to highlight the math within STEM (selected from Fractions; Truth, Lies, & Logic; Programming; Count without Counting; and Games & Strategies) and participated in open math time, where they worked on challenge problems. Based on previous evaluation of the camp indicating that the campers did not develop STEM identities or meaningful understandings of STEM, students participated in STEM-oriented activities on Fridays that focused on developing STEM identity, including hands-on activities (i.e., building and testing straw rockets) and STEM career information. See Table 1 for a description of the key components of the STEM Camp and the Appendix for a schedule.

Table 1

Key Components of the STEM Camp

Component	Description
Course Choice	If a student did not show mastery of division of fractions, as measured by the Admissions Challenge, then they were required to take the Fractions course. Otherwise, students chose which classes they wanted to take.
Open Math Time	During Open Math Time (OMT), students decide if they want to continue to work in their classes or go to another room to work with their peers on a Challenge Problem. In OMT, students decide which problem they want to work on with their peers and receive awards based on the number of problems solved.
25 Problem Challenge	At the beginning of the week, eight to 10 Challenge Problems were given to the students. Three times a day, students work collaboratively with their peers, with the guidance of a fellow, to solve the problems. When students solved the problem correctly, they wrote their names on the publicly displayed problem on the wall.
Circles	On Fridays, students learned about high-interest, STEM-focused topics such as DNA extraction, problem-solving through puzzles or games, and science or math lessons that prioritized STEM identity.
STEM Activities	On Fridays, students experienced STEM hands-on activities that included testing straw rockets, building and racing model cars, and observing and modeling an aquifer.
Weekly Activities	Every week of camp, students pick one activity to participate in daily. Activities included arts and crafts, chess, other games (card and board games), gym, film, and frisbee.
Team Time	Twice a day, students met with their teams, which were led by two or three fellows, to build relationships with each other, incorporate SEL practices, reinforce positive STEM identity amongst campers, celebrate growth and accomplishments, and have fun.

iSTEM Summer Institute

The iSTEM Summer Institute took place over 4 days during the summer with 10 math and science teachers from all school levels. All teachers had completed the MTR residency program prior to participating in the institute. The institute was developed and led in partnership by both the educational researchers as well as MTR Science Department Chair and Instructional Coach (these three are referred to as the “Summer Institute Team”). The institute was developed through regular meetings during the spring semester and was based on the research described above about supporting both student and teacher STEM identity. For the initial delivery of the iSTEM Summer Institute, teachers who had completed the MTR residency program and were currently teaching at any grade level in science, math, or a self-contained classroom were invited to participate.

To begin recruitment for teacher participants in the iSTEM workshop, the team made a concerted effort to inform teachers about STEM identity and increase interest in the topic. First, monthly MTR math and science newsletters were used to send out resources and information on STEM identity. Next, the first and second authors led a session at MTR University (MTRU), MTR's professional development program, on STEM identity to provide a baseline of the research behind STEM identity and practical ways to implement STEM identity in the classroom, short-term and long-term. Finally, MTR reached out to all science and math teachers to encourage them to apply for the iSTEM Institute and used feedback from the MTRU session to highlight the impact of learning about STEM identity could have in the classroom. Twelve teachers initially registered, 10 completed the summer institute, and nine consented to the research process. See Table 2 for participant details.

Table 2

Participant Details

Participant	Race	Gender identity	Grade level	Subject taught	Years teaching
Katelyn	Pacific Islander/White	Woman	Middle school	Science	1
Latoria	Black	Woman	Elementary	Science	6
Katherine	White	Woman	High school	Science	1
Vanessa	Black	Woman	Elementary	Science	3
Jessica	White	Woman	High school	Science	4
Jayla	Black	Woman	Middle school	Science	2
Daniel	White	Man	High school	Math	3
Chelsea	White	Woman	High school	Math	3
Rachel	White	Woman	Middle school	Science	2

During the iSTEM Summer Institute, teachers participated in 4 days of professional development focused on STEM identity (see Table 3 for an overview of activities). Teachers met for 6 hours per day, with embedded reading and reflection time. At the beginning of the institute, the facilitators led a conversation about the definition of STEM based on the teachers' various backgrounds and the focus of the STEM Camp. For the purposes of the institute, teachers were asked to define STEM however it was meaningful for them, with some teachers focusing specifically on science or math identity (if that is what they taught) and others focusing on more integrated models of STEM (especially elementary teachers who taught both science and math). In the article, STEM is used as an inclusive term to include any science, math, or integrated STEM teachers, and we refer to any of these conceptualizations as "STEM Identity." For the first 3 days, professional development focused on understanding STEM identity, knowing yourself and your students, and planning to support STEM Identity. The first few days were focused on building a theoretical understanding of identity in general and science and STEM identity in particular. This theoretical foundation was based on Carlone and Johnson's (2007) framework for science identity, which includes three components: performance, recognition, and competence.

(Adjustments were made throughout the institute by a math education expert to ensure the content was applicable and relevant to the math teacher participants.) This framework was introduced after teachers completed an activity sharing their high and low moments in STEM. Teachers recorded these moments on sticky notes to share with the larger group. After briefly introducing the concept of STEM identity, the group then connected the high and low moments to the framework by grouping them according to the three components. For example, many participants had high moments related to doing hands-on activities and exploring science; these were grouped as performance. Other moments were related to doing well in science, in terms of grades or class assignments; these were grouped as competence. Finally, some teachers explicitly mentioned feedback from teachers, both positive and negative; these moments were grouped as recognition. At this point, teachers also completed a self-reflection based on the following questions.

- Does your ideal of a STEM student align with future success in STEM?
- Are you giving your students opportunities to perform identities as good STEM students?
- Are you providing recognition for those characteristics that are valuable in STEM?
- Are you able to perform (and gain recognition) an identity as a good STEM teacher?

Finally, teachers completed a “chalk talk” exercise in which they brainstormed classroom strategies that would support STEM identity in terms of performance, recognition, and competence.

Table 3

Overview of iSTEM Summer Institute

Day	Aims	Summary of activities
1	Introduction to STEM Identity: • Understand the impact of STEM identity and its relationship to social justice • Explore the role of the teacher in supporting student STEM identity	• Teachers share high and low moments in STEM. • *Equity and Representation in STEM:* Teachers explored a set of graphs using NSF data on the representation of women and people of color in STEM areas. • *STEM Identity Framework:* Teachers were presented with an identity framework of performance, recognition, and competence (Carlone & Johnson, 2007) for understanding the underrepresentation of women and people of color in STEM. • *Teacher Identity:* Teachers engaged in an exploration of their own identities, using Mensah's (2012) positionality cards and Milner's (2020) reflection questions on race and teaching.
2	Student STEM Identity: • Understand the intersections of multiple student identities • Develop strategies to value student identity	• Teachers share objects that represent STEM to them. • *STEM Identity for Students:* Teachers participate as students in a common STEM activity and reflect on how they perceived their identity during the activity. • *Culture-Learning-Identity (CLI) Framework:* Teachers are presented with the CLI Framework for understanding the relationship between students' cultures and their STEM identities. • *Lesson Plan and Textbook Evaluation:* Teachers use the identity frameworks to evaluate their curriculum through the perspective of identity. • *Student Interviews:* Teachers plan, conduct, and reflect on interviews with STEM campers.
3	Planning to Support STEM Identity: • Understand how pedagogical decisions impact student and teacher identity	• *Culturally Relevant STEM Lessons:* Dr. Jacqueline Leonard presented her perspective and understanding of STEM identity and led a series of activities designed to support students' STEM identities. • *Pedagogical Strategies for Supporting STEM Identity:* Teachers discussed overlaps between activities that support STEM identity and other pedagogical frameworks, such as 5E lesson planning, culturally relevant pedagogy, and three-dimensional science instruction. • *Lesson Planning:* In groups, teachers began developing a lesson for STEM campers based on lessons learned from student interviews and their own understanding of STEM identity.
4	Working with Students: • Gain experience with identity-focused instruction	• *Lesson Delivery:* Teachers finalize lessons and lead lessons for a group of STEM campers. • *Final Reflection:* Teachers reflect on their experience delivering lessons throughout the week and set and share intentions or goals for the upcoming school year.

Teacher Identity Activities

Building on this framework of identity, teachers then explored their own identities through two reflective activities. First, they completed Mensah's (2012) positionality card sort activity in which they identified which identities are most relevant to them as an educator. In this activity, identities such as gender, race, ability status, and age are arranged so that the most relevant identity cards are placed closest to the individual. After completing the card sort activity, teachers shared their results with the group. This led directly to a conversation about the role of racial identities in the classroom and another reflective activity guided by the following reflection questions (Milner, 2020).

- How does my race influence my work as an educator with my students, particularly with students of color?
- As an educator, what is the effect of race on my thinking, beliefs, actions, and decision-making?
- How do I, as an educator, situate myself in the education of students, and how do I negotiate the power structure in my class to allow students to feel a sense of worth regardless of their racial background?
- How do I situate and negotiate students' knowledge, experiences, expertise, and race with my own?

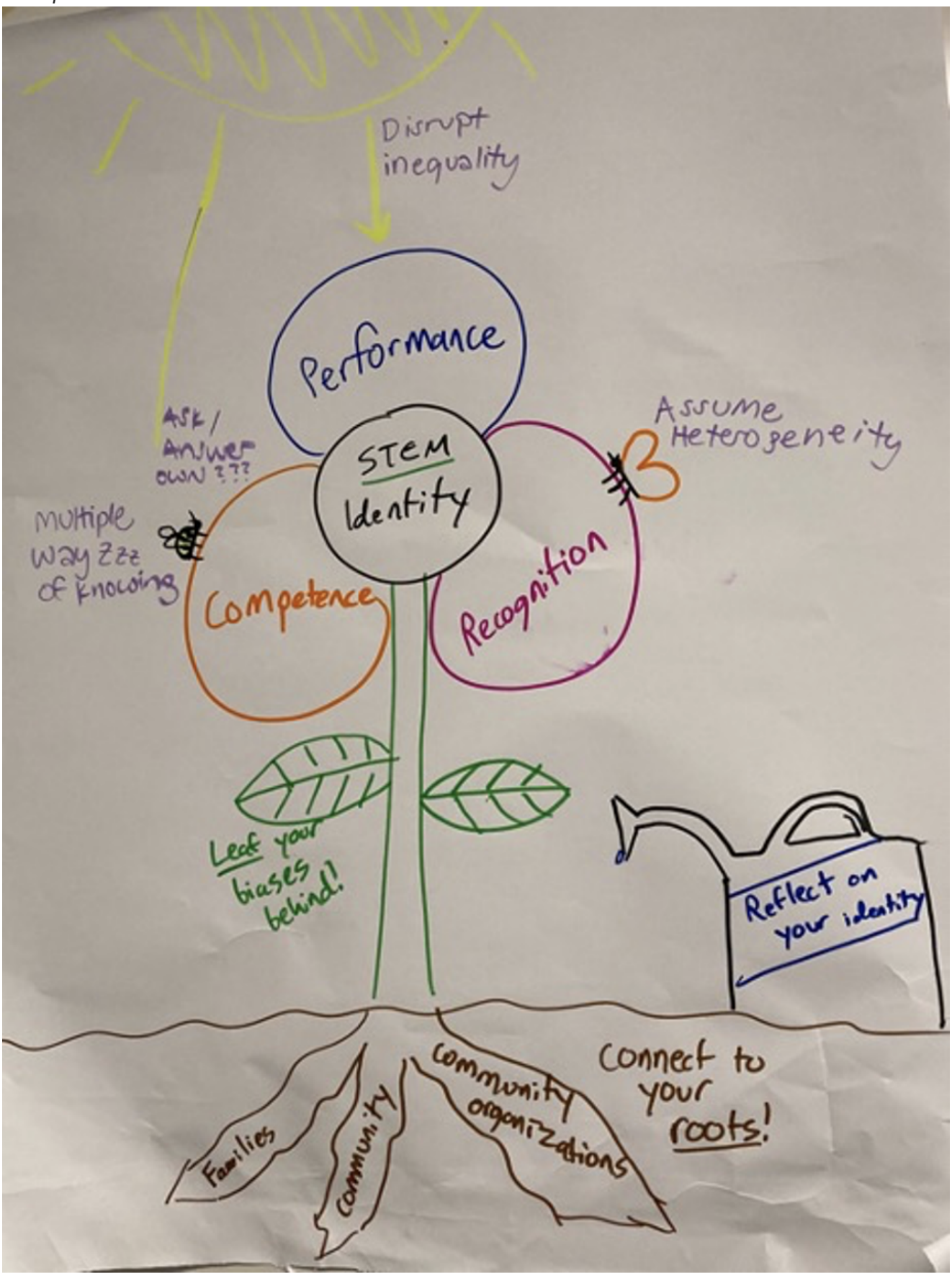
Understanding Student Identity

On the second day, teachers began to explore ways to understand, acknowledge, and leverage students' cultural identities in the classroom and to develop STEM identity. This built directly on the previous day's discussion about teacher identity and the ways in which teachers and students have different backgrounds, most noticeably in terms of race (particularly for the White teachers in the group who taught primarily students of color) but also in terms of other variables such as language, gender, and socioeconomic status. This exploration was done through two activities: an exploration of the Culture, Learning, and Identity (CLI) Framework (Learning in Places Collaborative, 2020) and interviews with campers. Teachers first read and discussed the CLI Framework overview (Learning in Places Collaborative, 2020), which explicitly focuses on equity in science teaching and learning. We presented this framework on the second day as a more practical framework to complement the theoretical framework introduced on Day 1. The CLI Framework includes more specific actions that teachers can take to support the identity development of students from all cultures, including actions that were purposefully included in the summer institute, such as reflecting on your own identity and locating science and STEM in the community. In order to support teachers in connecting the theoretical identity framework with the more practical CLI Framework, they worked in small groups to create concept maps of how the CLI and Identity frameworks interacted. Figure 1 gives an example of how teachers connected specific components of CLI to each of the three components of identity as well as how they viewed

other tenets of CLI as setting a foundation for identity work in the classroom. Finally, teachers completed the CLI self-assessment (Learning in Places Collaborative, 2020) and shared areas they felt strong in and areas in which they wanted to improve.

Figure 1

Example of Combined Frameworks



Key Components of Research-to-Practice Partnership

Student Interviews

On the second day of the institute and camp, teachers developed and conducted STEM-identity-focused interviews with small groups of campers, using questions the teachers generated. The teachers were paired according to their grade band and content area and were then given time to brainstorm questions. During the brainstorming session, teachers discussed what they would like to learn from campers, how to get youth to share information in both traditional (question and answer) and nontraditional ways (i.e., drawing pictures), and how to ask about STEM identity. Teachers were asked to reflect specifically on the components of STEM identity discussed in the institute (performance, recognition, and competence) and generate questions or other activities to learn more about students' perceptions of each component. Each pair of teachers shared the questions they selected with the whole group and then finalized their questions. Some questions teachers asked included the following:

- "What do you like about your science/math/STEM class? What do you not like?"
- "Are you good at science/math/STEM? How do you know? Do other people think you're good at science/math/STEM?"
- "Draw a picture of yourself doing science/math."

Then, teachers were matched with groups of five STEM campers and given 30 minutes to conduct the interviews. During the interviews, teachers took written notes. After the interviews, teachers completed individual written reflections and then participated in an affinity mapping exercise based on the interviews. First, teachers individually recorded key takeaways from the interviews on sticky notes. For example, one teacher recorded the following: "Did not feel recognized much by teachers," "favored hands-on activities (not surprising)," "all said they were good at science," and "did not like writing because [of the] 'long and hard words I don't know.'" Then, in two groups of five (one person from each interview group), teachers considered all of the sticky notes and categorized them. Categories included "teacher actions/exploration," "student mindset/inner voice," "STEM learning environment," "what is STEM," and "STEM Success (external)." A whole group discussion then followed about themes among both groups and the implications of this information for student identity development. Teachers discussed that youth expressed that they enjoyed hands-on, challenging activities; that they already had a strong STEM identity, but it was not necessarily connected to recognition at school or from their teachers; and that youth needed the right tools or resources to engage in meaningful STEM work.

Lesson Development and Delivery

At the end of the iSTEM Summer Institute, teachers developed and delivered 1-hour, identity-focused STEM lessons for the STEM campers. Working in the same partner pairs from the interviews, teachers used both what they had learned from youth during the interviews as well as what they had learned about STEM identity during the professional development in order to develop their lesson. Teachers were encouraged to start with an existing activity or topic and consider how to adjust the activity to support identity. Groups shared their ideas and received feedback from other teachers and then delivered their lessons to STEM campers on the final morning of the iSTEM Summer Institute.

For example, one group took an existing activity of building roller coasters out of pipe insulation and highlighted aspects that would make it more supportive of identity. In the original activity, groups of students would build roller coasters for marbles using pipe insulation. Groups would have to meet certain specifications (i.e., include hills or loops) for the roller coaster and would receive a grade from the teacher based on how well they met those specifications. The teachers identified this as an activity that was very hands-on, something campers indicated was important in the interviews. Building on this already engaging activity, this group revised their lesson to focus on the CLI tenets of "recogniz[ing] and engag[ing] multiple ways of knowing" (Tenet 2) and giving students power in the classroom (Tenet 7) by providing "opportunities for learners to ask (and answer) their own questions" (Tenet 4; Learning in Places Collaborative, 2020, p. 3). First, the group elicited campers' experiences with roller coasters and provided time to share those experiences with the whole group, highlighting how everyone had different experiences. Next, instead of providing specific directions for how the roller coasters should be constructed, they encouraged campers to use their experiences to design a roller coaster they would enjoy, stressing that there was no right or wrong way to design the roller coaster. By providing time for campers to share their experiences and encouraging them to use those experiences in their designs, the teachers were working to highlight students' multiple ways of knowing. Although it may seem trivial to focus on experiences with roller coasters, the teachers viewed this as an entry point for acknowledging the diverse backgrounds and experiences in their class. Additionally, the teachers saw these revisions as a way to give the campers more power in the classroom by allowing them freedom over their designs and giving them opportunities to ask each other questions about their roller coaster designs. Throughout the lesson, the teachers consciously referred to the campers as "roller coaster engineers," providing explicit recognition for campers. Finally, instead of a teacher-assigned grade, the teachers left time for the campers to demonstrate their roller coasters for the rest of the group and receive feedback from their peers, adding an additional element of peer recognition from the identity framework.

Outcomes

MTR and the STEM education researchers all had the same overarching goal of supporting social justice in and through STEM education, which served as the foundation of this research-to-practice partnership. MTR also had a goal of providing support and professional

development for teachers in STEM, specifically regarding how to support STEM identity both at STEM Camp and in classrooms (based on results from previous STEM Camps). The researchers had a goal of exploring how teachers develop their own identities as well as how they support student STEM identities. With these aligned goals, each group contributed to the partnership in ways that ultimately supported teachers through robust professional development that included opportunities to interact with youth. MTR contributed practical and logistical support to the partnership: helping recruit participants to the summer institute through their existing networks, providing access to the STEM Camp and campers, and arranging logistical details such as meeting space and times for the teachers and campers to interact. The researchers contributed theoretical and research support to the partnership, including expertise in STEM identity for both teachers and students that served as the foundation of the Summer Institute and feedback to MTR on how to integrate STEM identity into their programming (including the STEM Camp). Below, we describe how these contributions came together in support of science teacher development in particular.

Benefits of a Research-to-Practice Partnership for Teacher Development

Following the iSTEM Summer Institute, participating teachers were interviewed about their experience. All teachers indicated that the institute was valuable to them as a STEM teacher and specifically pointed out the usefulness of having a framework for identity to understand STEM teaching and learning (researcher contribution) as well as the value of having time to work with STEM campers to understand student identity and put their theoretical understanding of identity into practice (MTR contribution). These two pieces of feedback, described below, were common in almost all teacher interviews and demonstrate the power of the research-to-practice partnership.

Theoretical or Researcher Component

When considering the summer institute, the science teachers described the value of having a theoretical framework to make sense of teaching science and STEM in general and specifically highlighted the value of an identity framework when considering their goals of teaching for social justice. The theoretical understanding, based on the research of the first and second author on STEM identity, demonstrates the researcher role in the partnership. Describing the institute generally, Jayla (all names used are pseudonyms), a middle school science teacher, said, “I feel like it’s really helping me as a first-year teacher [to] be better equipped as a science teacher and to support my students in a way that they deserve.” In interviews, participants reflected on how the identity framework provided a useful perspective for understanding their science teaching practices holistically. For example, Jessica, a high school science teacher, said, “Just seeing how it is really like all encompassing . . . like the competence, performance, recognition . . . even if a student doesn’t go on to pursue a STEM career.” Other participants indicated this shift in perspective as well, saying: “It’s made me more conscious of what I teach and how I teach it” (Jatoria, elementary school science teacher), and “it was challenging and thinking about my lessons in a new way” (Jayla). Using

the framework, science teachers indicated that it helped them understand why it was important to do (perform) science in class, as well as to explicitly recognize students doing science.

Practice Component

Another specific component of the institute that science teachers felt was impactful was the combination of opportunities to interact with youth, both interviewing campers early in the week and then facilitating a STEM activity with them later in the week. As Katelyn, a middle school science teacher, explained, “Having the practical application of going and talking with the STEM students and being able to teach them, I think it wouldn’t have been as impactful if we didn’t have that planning piece.” Other science teachers reflected specifically on how the theoretical framework combined with practical activities was helpful for not just understanding identity but supporting it in the classroom. As Jessica explained, “I knew I really wanted to help students see themselves as scientists, but I think . . . I would say this helped me have a deeper understanding of how I could practically help students to see a reflection of themselves and science.” Similarly, teachers indicated how using the identity framework helped them improve their science pedagogy and evolve as science teachers. Jayla explained this process:

> I feel like I already had some pretty good ideas as to how—how to get students engaged and listen . . . . And they were already going to have this opportunity to really do science themselves, but it’s definitely challenged me to think about how I’m going to get students to see themselves . . . . Rather than just being scientists, but again the reflection of their own cultures, I feel like that’s really important.

Connecting Theory and Practice

Finally, science teachers indicated that having the practical components and reflection time helped them make sense of the theoretical foundations of the institute. As Jayla explained,

> I feel like early on in the week, some of the more like overview theoretical discussions felt a little bit like ‘Okay, but like how do I implement this . . . .’ And I did, by the end of the week, I didn’t feel like they were.

This highlights the importance of both pieces of the research-to-practice collaboration because they were evident in the iSTEM Summer Institute (theory and practice) as well as the need to provide support to make connections between these two components.

Challenges and Next Steps

Although we view this first year of collaboration between researchers and practitioners as a success, it was not without challenges. We were incredibly lucky to work with a group of teachers who were already invested in teaching STEM for social justice and who were open

and prepared to engage in sometimes difficult and uncomfortable conversations about culture, race, and different backgrounds. Not all teachers will be prepared in the same way for these conversations, and for some groups of teachers, prework may be necessary. Many teachers hold deficit views of students and communities, particularly in urban areas, that would need to be addressed before being able to meaningfully engage with this type of professional development (Bryan & Atwater, 2002; Jacobs, 2015). Because MTR has an explicit focus on social justice, the MTR-affiliated teachers we recruited were ready and willing to do this work. Other forms of recruitment, including district-wide recruitment of teachers, would need to be explicit about the type of work that will be done during the professional development. Recruiting from a larger pool of teachers with different backgrounds and experience levels may also mean building in some time to develop a baseline understanding of social justice and equity in education.

Although the teachers who were part of this initial program were starting from similar points, that does not mean that we did not have to be flexible with the professional development offered and adjust to teachers' needs as well as logistical challenges, particularly pertaining to presenting STEM activities to campers. For example, on the third day, the summer institute team sensed that teachers were still nervous about developing activities for the campers. To address this, we adjusted the schedule to include presenting teachers with examples of activities that they may be familiar with and how they could adjust those activities to focus more explicitly on identity. Additionally, coordinating the iSTEM Summer Institute, STEM Camp, and guest speaker schedules was a challenge and resulted in some last-minute shifting of activities.

Finally, financial resources are needed for this type of work. Although the STEM Camp was already funded before this collaboration, the iSTEM Summer Institute was not. A small amount of funding was obtained from one of the affiliated universities, which made it possible to provide stipends for teachers and support researcher travel. However, this is not always possible. We believe it is possible to conduct such a session without funding as long as the nonfinancial benefits are clear to teachers, researchers, and partner organizations. For this collaboration, the teachers initially registered for the summer institute before funding was secured, so they were willing to participate without the promise of a stipend. As researchers, we also gained in terms of the opportunity to conduct novel research that we are passionate about with strong logistical support (e.g., recruitment, facilities, and access to teachers and STEM campers) from MTR. Finally, MTR gained an opportunity to provide professional development for their teachers and address a noted need of their STEM campers without having to hire external consultants.

Through this collaboration, we have also identified areas of ongoing work. First is the continuous support of teachers. Research has shown that effective professional development needs to have enough hours but also should be ongoing over time (van Veen et al., 2012). Our teachers echoed this need, indicating at the end of the institute that although they benefited from the work, they wanted opportunities to connect throughout the

academic year. Second, evaluation of the impact of this collaboration on students (both STEM campers and in participating teachers' classrooms) would help strengthen and expand the professional development aspect.

Strategies for Implementation

The collaboration presented here has been rewarding in ways that we did not originally imagine. Beyond the obvious benefits of being able to conduct research that is meaningful for us and provide quality professional development and support for teachers and youth, we have also all found motivation, support, and encouragement through working together toward our shared goals of providing more equitable STEM education to youth who have been historically and systemically excluded from STEM.

This collaboration, although beneficial for all parties involved, initially began somewhat by chance—through various introductions and "right place at the right time" scenarios. However, we believe that there are other potential collaborations that might be missed when many different entities are engaged in the work of preparing and supporting teachers in silos. In many areas, there are organizations working to prepare and support teachers from the practitioner side who often need help developing high-quality professional development for teachers. There are also researchers who are developing innovative approaches to supporting teachers who struggle to gain access to or recruit teacher participants. We suggest that both parties could benefit from more proactive partnering and that the science education community in general would benefit from more interaction among groups. We encourage educational researchers to get to know their own educational contexts and think beyond traditional teacher preparation programs and school districts to look for partners in nonprofits and other community-based groups actively working to support teachers and students who may not know about the educational research resources in their own communities. By developing meaningful partnerships across individuals and organizations interested in STEM education, we can begin to more fully promote STEM equity through identity for both teachers and students.

Supplemental Files

Wade-Jaimes-et-al.-appendix.docx

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