Coaching Teachers to Support STEAM in a Middle School Community of Practice
(Work in Progress)

Abstract

This work in progress paper describes the impact of using a coaching strategy to promote learning about engineering and funds of knowledge. Preliminary analysis of the data indicated that strategies used throughout the research were effective primarily because the teachers constantly received immediate feedback. In addition, recognizing teachers as experts was important for the development of productive and asset-based collaborations. Teachers indicated that they valued the tools provided to them, which served to mediate their learning of and about engineering. This research indicates that *confianza* is fundamental to create spaces that foster collaborative work with teachers' communities of practice.

Introduction

The current state of STEM education has created a national call to integrate and promote engineering-oriented education throughout PK-12 schooling for all students, including those classified as English Learners (ELs). To date, however, there has been little research on effective ways to support PK-12 teachers — usually with little background knowledge and experience in engineering themselves. Studies have mostly highlighted successful ways in which teachers overcome challenges when implementing engineering into their classrooms or the curriculum rather than diving deeper into institutional challenges that teachers face during this process [1-5]. Some of these strategies include incorporating new engineering design activities [1], supplementing instruction through summer programs [2, 3], or learning about the engineering design model [4, 5].

At the forefront of this conversation is how teachers (who for the most part have no formal training in engineering) position themselves, how the school administration tries to position them, and how policy may impact the position they take in the midst of changing standards. For instance, Lesseig, Slavit and Nelson described the challenges teachers face when implementing STEM [1]. They observed that not only does the implementation of STEM activities require resources, but the implementation often does not fit into the traditional school structure which separates mathematics, engineering, and science content. This issue is typically circumvented by incorporating "STEM days" throughout the school year, but learning about engineering is frequently seen as a hurdle by teachers and assumed to be deliberately integrated in STEM activities [1]. Even more issues emerge as teachers are asked to facilitate STEM teaching and learning for students classified as English Learners (ELs). Bilingual teachers, in particular, are faced with the challenge to integrate language and STEM content [6, 7], where expertise in science vocabulary is often seen as a must rather than helping the students learn through conceptual understanding [8] while sustaining the linguistic practices of the students.

Despite the national call to integrate engineering in PK-12 settings, there are still several challenges that emanate from instructional practices including the nature of the materials available to teachers, teacher confidence to adapt new approaches to teach engineering, and language and STEM content integration. As such, PK-12 teachers provide students with their first exposure to engineering while potentially working with little or no guidance, which – from an equity perspective – may tend to benefit students who are exposed to engineering at home.

In this paper, which is part of a larger study, we describe our efforts to provide tools and training to teach engineering through a STEM coaching strategy. To accomplish this objective, we recruited eight teachers at a STEAM-focused middle school to participate in a two-year program where different strategies were

shared and put into practice. Most participating teachers were Latino/a/x teachers. The research team coached teachers to create and adapt engineering lessons for their students, which included a high percentage of students classified as ELs. Together we created a community of practice that fostered *confianza* (trust) [9] and *colaboración* (collaboration) where teachers could share and have access to expertise from member of the community of practice, and facilitated through both formal and informal interactions. These strategies were intended to serve as a resource for collaborative reflection and deeper learning of and about engineering and funds of knowledge. Three researchers with expertise in engineering, bilingual education and learning sciences facilitated the coaching sessions where workshops, monthly meetings, and other tools were used to help teachers mediate their own learning. We were guided by the question: what strategies are most helpful in developing teachers' understanding and elicitation of students' funds of knowledge? This work-in-progress paper describes the coaching strategy and the tools that mediated learning throughout the project.

Theoretical Framework

An emerging body of research literature on coaching strategies for educational settings suggests its potential for STEM education. For example, one study drew from strategies developed for school transformation and leadership to guide the coaching of teachers [10]. Central to this approach was the concept of dialogue, where the main goal was to increase awareness and developing teachers' agency [11]. Coaching models for transformation and leadership draw from these guiding principles: (1) considering the context of the school, (2) facilitating reflection on ways of knowing and doing, beliefs, and behaviors, (3) setting goals for the program, (4) building *confianza*, (5) co-constructing curricular engineering-focused materials for implementation in the classroom, (6) fostering culturally and linguistically relevant aspects through a funds of knowledge approach, and (7) maintaining a constant physical presence [12, 13]. We argue that this coaching model in combination with different artifacts (e.g., guides, templates, articles, physical manipulatives) serves the role of mediating learning for teachers.

For this research we also drew on sociocultural understanding of learning. In this tradition, learning is considered to be situated in communities of practice [14]. It means that learners become apprenticed into ways of acting and being in the world, such as when a novice craftsperson learns a new craft under the tutelage of a more experienced craftsperson. Further, a sociocultural perspective also considers the material objects that mediate learning. In communities of practice, learners are socialized into understanding the use and meaning of tools. As learners become apprenticed into ways of being and acting in the world they take up different identities [15, 16] as well. Tools mediate learning in situated contexts. Artifacts are "the means by which figured worlds are evoked, collectively developed, individually learned, and made socially and personally powerful" [15, p. 61].

Thus, the coaching strategy for this study relied on the idea of co-constructing knowledge through a collective use of practices familiar to the teachers, and creating value in the teaching of engineering and funds of knowledge. In the context of engineering learning at the school site, we aimed to create a community of practice– a community with a common goal to apprentice teachers into ways of being. We developed a coaching strategy in which we engaged with teachers as colleagues. We adopted a coaching strategy where the coaches (i.e., research team members with expertise in learning sciences, engineering education and bilingual education) served in the role of coaches who guided the teachers through the process [10, 17].

We developed materials and tools (e.g., artifacts) to mediate learning about engineering and funds of knowledge [18-21]. Such artifacts included templates that helped guide the engineering design process, slides with examples of funds of knowledge and engineering, documents with examples of engineering

problems, and strategies to integrate STEM content and language, among others. These artifacts became fundamental for the understanding of concepts and the significance of engineering and funds of knowledge throughout the project. Mediation in this case applied to both objects and people [15], and in this study the coaches provided meanings, associations, and interpretations to the artifacts used throughout the project. Thus, the combination of artifacts and coaches (guided by the coaching model) served the purpose of enhancing learning about engineering and funds of knowledge, which would not have been possible without such tools [10, cf., 22]. The following sections describe the ways in which this approach was implemented for this study and the result obtained.

Methodology

This paper is part of a larger study conducted with eight teachers from a STEAM-focused middle school in the U.S.-Mexico border [18-21]. Participating teachers included 2 males (1 science teacher and 1 social studies teacher) and 6 females (2 science teachers, 1 mathematics teacher, 1 English teacher, 1 Spanish teacher, and 1 social studies teacher). Teachers from different subjects were selected because the principal supported the idea of working as interdisciplinary teams and integrating STEAM throughout the curriculum. All teachers were bilingual (English/Spanish) and served a large population of students classified as English Learners. The school was classified as a Title I school, where approximately 88% of the students received free or reduced lunch. In addition, the school served a large number of transnational students.

All teachers participating in the study were asked to collaborate with the research team to develop an engineering-focused activity that could be implemented in their classroom. Initially, teachers received more than 25 hours of professional development in the form of workshops, which included summer sessions where teachers learned about funds of knowledge, engineering design, aligning activities to Next Generation Science Standards' science and engineering practices [23], teamwork, and ways to integrate linguistic practices into their lessons. After the summer professional development, monthly follow-up sessions were facilitated for the whole team of teachers. In addition, in one-on-one sessions between the coaches (i.e., research team investigators) and the teachers were used to check-in with them and review the progress made on their activities. The professional development, follow-up meetings, and one-on-one sessions were used to discuss and implement aspects of the coaching strategy mentioned earlier (i.e., (1) considering the context of the school, (2) facilitating reflection on ways of knowing and doing, beliefs, and behaviors, (3) setting goals for the program, (4) building *confianza*, (5) co-constructing curricular engineering-focused materials for implementation in the classroom, (6) fostering culturally and linguistically relevant aspects through a funds of knowledge approach, and (7) maintaining a constant physical presence). Moreover, tools were developed and used in these sessions to mediate learning including a guide to help students follow the engineering design process, data gathering and analysis tools in the form of Excel sheets, Jamboards, and reading materials. As coaches, the research team also contributed to the mediation of learning by facilitating sessions for inquiry among teachers, discussing and analyzing language demands of English Learners, and providing immediate feedback. After the COVID-19 pandemic emergency response was declared in the state and across the country, coaching shifted to a remote modality facilitated primarily through Zoom and Google Meets since teachers used Google Classroom for the delivery of their classes.

Data were collected through interviews, observations, group meetings and field notes. We conducted 30–40-minute interviews with teachers at the end of every year of the study to determine teachers' perspectives regarding the benefits of using students' funds of knowledge, their levels of confidence in terms of their classroom activity development and implementation, and how the coaching strategies contributed to the teaching and learning of engineering. We also observed the teachers' classroom and

collected field notes to determine how the activities were being implemented, observe the response from students, and analyze the effectiveness of the coaching model. Finally, we conducted monthly group meetings throughout the semester to check in with the teachers. One of the components of the coaching model was to maintain a presence in the community of practice and develop *confianza*; therefore, these group meetings helped to develop that trust among participants, listen to their concerns, and provide support and guidance when questions came up. We used these data to help answer the question: what strategies are most helpful in developing teachers' understanding and elicitation of students' funds of knowledge? Thus, data collected was initially analyzed using a combination of open coding and descriptive coding [24]. This work in progress presents only preliminary results obtained from the initial analysis.

Preliminary Results

The collection of strategies used throughout the project provided support to the teachers both in person and remotely. The workshops, follow-up meetings and one-on-one meetings exposed teachers to applications and methods they would be able to use with their students (primarily remotely). Modeling for the teaches how to facilitate engineering activities was one of the strategies used. Teachers appreciated the experience of being virtual learners and how they could draw on those experiences to teach their students through distance learning. One of the participating teachers highlighted the importance of modeling:

> I remember during the online [workshop] that we had this past summer, I remember that they showed us how to do engineering activities through, through distance learning. So they were modeling - so this is something that you can do, this information can be relevant. (Mathematics teacher, interview data).

Additionally, the coaches (i.e., the research team) provided the teachers with practical templates for designing engineering lesson plans, self-evaluating their lesson plans on a rubric incorporating funds of knowledge and the engineering design process, and lesson plans they could use with their classes. The teachers thought the templates were very helpful and set clear expectations for the upcoming school year:

> I was pretty confident before but I think that even the template on the engineering design cycle gave me another tool because I had been using other ones that I just developed on my own. So it allowed me to kind of marry ideas that I already had with ideas that they presented and tried to figure out a format that makes the most sense for our kids and going through the process of engineering. (Spanish teacher, interview data).

The templates were used to mediate learning about engineering design through guided learning, which is particularly important for teachers whose background is not engineering but may be pushed to integrate such practices into their classes. Also, the teachers appreciated that each of the coaches offered a different approach and set of strengths, and that they were able to call on each other for support if something was out of their own area of expertise while receiving immediate feedback. The teachers agreed that it was helpful to call upon each other:

> It was very accessible to have [another coach] hop onto a Zoom meeting with [one of the coaches] and with the teacher to give them the specific things related to science and engineering that I didn't know, and so that worked well. (Spanish teacher, interview data).

Finally, teachers were able to integrate funds of knowledge and engineering through project-based learning and developed in collaboration with the coaches. One of the teachers reflected on an activity where students engaged in designing, creating and testing face masks:

> We're really proud of it...we decided to take on the engineering standards of our eighth-grade year at the beginning. We were really talking about human impact and environmental problems, and we were also looking at the pandemic. So we just decided to tie both ideas together as the engineering problem. (Science teacher, interview data).

Discussion and Future Work

Preliminary results indicate that the coaching strategy creates a positive impact on teachers' understanding of concepts such as engineering and funds of knowledge. The coaching strategy also allowed for the creation of a space where linguistic diversity became the norm, sharing of ideas was welcomed, and co-creation of activities was fundamental. Coaches endeavored to develop a relationship of reliance and trust (*confianza*) with the teachers, which was very important for the coaching relationship. For instance, we developed *confianza* by facilitating sessions in both English and Spanish. The teachers themselves were bilingual and we used that linguistic diversity to connect with them. Thus, modeling those interactions helped create *confianza* with teachers and contributed to how the teachers began to acknowledge language as an important fund of knowledge.

Research has indicated that middle school teachers often feel unprepared to implement STEM activities due to the lack of resources, guidance, or familiarity with the content, as well as the activities being hard to accommodate in traditional lecture style classrooms [25]. The coaching model provides the space for dialogue, inquiry and creativity [13] rather than following a traditional banking model which has become a norm in professional development programs [10]. A positive correlation has been found between practices that encourage collaboration and co-creation and teachers' attitudes on integration, problem-centered, inquiry-based, design-based, and cooperative learning [26].

Preliminary analysis of the data indicated that caching strategies used throughout the project were effective primarily because the teachers constantly received immediate feedback. In addition, recognizing teachers as experts was important for the development of productive and asset-based collaborations. As a team, we relied on teachers' expertise and familiarity with their own classroom. It was important to reiterate and position teachers as experts of their own classroom, which facilitated building trust and strong relationships. Teachers also indicated that they valued the tools provided to them, which served to mediate their learning of and about engineering. Future work will focus on analyzing how teachers use these tools and what has been learned throughout the project to create their own mediating tools.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. 2211032 and 1826354. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

[1] K. Lesseig, D. Slavit, and T. H. Nelson, "Jumping on the STEM bandwagon: How middle grades students and teachers can benefit from STEM experiences," *Middle School Journal,* vol. 48, no. 3, pp. 15-24, 2017.

[2] R. Goonatilake and R. A. Bachnak, "Promoting engineering education among high school and middle school students," *Journal of STEM Education: Innovations and Research,* vol. 13, no. 1, pp. 15-21, 2012.

[3] M. J. Mohr-Schroeder *et al.*, "Developing Middle School Students' Interests in STEM via Summer Learning Experiences: See Blue STEM Camp," *School Science and Mathematics,* vol. 114, no. 6, pp. 291-301, 2014.

[4] M. M. Hynes, "Middle-school teachers' understanding and teaching of the engineering design process: A look at subject matter and pedagogical content knowledge," *International journal of technology and design education,* vol. 22, no. 3, pp. 345-360, 2012.

[5] P. Cantrell, G. Pekcan, A. Itani, and N. Velasquez-Bryant, "The effects of engineering modules on student learning in middle school science classrooms," *Journal of Engineering Education,* vol. 95, no. 4, pp. 301-309, 2006.

[6] L. Hogg, "Funds of knowledge: An investigation of coherence within the literature," *Teaching and Teacher Education,* vol. 27, no. 3, pp. 666-677, 2011.

[7] S. Selcen Guzey, M. Harwell, M. Moreno, Y. Peralta, and T. J. Moore, "The impact of design-based STEM integration curricula on student achievement in engineering, science, and mathematics," *Journal of Science Education and Technology,* vol. 26, no. 2, pp. 207-222, 2017.

[8] R. Benavides and W. Medina-Jerez, "No puedo: "I don't get it": Assisting Spanglish-speaking students in the science classroom," *The Science Teacher,* vol. 84, no. 4, pp. 30-35, 2017. [Online]. Available: https://www.jstor.org/stable/44249870.

[9] N. González, L. C. Moll, and C. Amanti, *Funds of knowledge: Theorizing practices in households, communities, and classrooms*. Mahwah, NJ: Lawrence Erlbaum, 2006.

[10] M. Giamellaro and D. R. Siegel, "Coaching teachers to implement innovations in STEM," *Teaching and Teacher Education,* vol. 76, pp. 25-38, 2018.

[11] J. Lock, "Personalizing educational development for online music educators: A coaching approach," in *Pedagogy Development for Teaching Online Music*, C. Johnson and V. C. Lamothe Eds. Hershey, PA: IGI Global, 2018, pp. 306-319.

[12] E. Aguilar, "You Can't Have a Coaching Culture without a Structure," *Educational Leadership,* vol. 77, no. 3, pp. 22-28, 2019.

[13] E. Aguilar, *The art of coaching: Effective strategies for school transformation*. John Wiley & Sons, 2013.

[14] J. Lave and E. Wenger, *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press, 1991.

[15] D. Holland, W. Lachicotte Jr, D. Skinner, and C. Cain, *Identity and agency in cultural worlds*. Cambridge, MA: Harvard University Press, 1998.

[16] D. Holland and J. Lave, "Social practice theory and the historical production of persons," *Actio: An International Journal of Human Activity Theory,* vol. 2, no. 1, pp. 1-15, 2009.

[17] S. Severance, W. R. Penuel, T. Sumner, and H. Leary, "Organizing for teacher agency in curricular co-design," *Journal of the Learning Sciences,* vol. 25, no. 4, pp. 531-564, 2016.

[18] J. Mejia, D. Ruiz, V. Popov, A. Esquinca, and D. Gadbois, "Asset-based Practices in Engineering Design (APRENDE): Development of a Funds-of-Knowledge Approach for the Formation of Engineers," in Proceedings of the 2019 ASEE Annual Conference & Exposition, Tampa, FL, 2019.

[19] J. A. Mejia, M. Arana, M. Roberto, and N. Reyes, "¿Por qué no los dos? The Importance of Translanguaging in Bridging Language, Literacy, and Engineering," in Proceedings of the 2020 American Society for Engineering Education (ASEE) Annual Conference, 2020.

[20] J. A. Mejia, A. Esquinca, V. Popov, M. Arana, M. Roberto, and N. Reyes, "Integrating Asset-based Practices, Engineering, and NGSS: Lessons from Working with Teachers through a

Community-focused Approach," in Proceedings of the 2020 American Society for Engineering Education (ASEE) Annual Conference, 2020.
[21] J. A. Mejia, L. R. Betancourt, A. Esquinca, and V. Popov, "Teachers Navigating Educational Systems: Reflections on the Value of Funds of Knowledge (Fundamental)," in 2021 ASEE Virtual Annual Conference Content Access, 2021.
[22] J. P. Gee, *Social linguistics and literacies: Ideology in discourses*, 3rd ed. London: Routledge, 2008.
[23] NGSS Lead States, *Next generation science standards : for states, by states*. Washington, District of Columbia: National Academies Press (in English), 2013.
[24] J. Saldaña, *The coding manual for qualitative researchers*, 2nd ed. Thousand Oaks, CA: SAGE, 2015.
[25] M. Gardner and J. W. Tillotson, "Interpreting integrated STEM: Sustaining pedagogical innovation within a public middle school context," *International Journal of Science and Mathematics Education,* vol. 17, no. 7, pp. 1283-1300, 2019.
[26] L. Thibaut, H. Knipprath, W. Dehaene, and F. Depaepe, "Teachers' attitudes toward teaching integrated STEM: the impact of personal background characteristics and school context," *International Journal of Science and Mathematics Education,* vol. 17, no. 5, pp. 987-1007, 2019.