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Place Based STEM: Leveraging Local Resources to Engage K-12 Teachers in Teaching Integrated STEM and for Addressing the Local STEM Pipeline

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Place-based STEM: Leveraging Local Resources to Engage K-12 Teachers in Teaching Integrated STEM and for Addressing the Local STEM Pipeline

Abstract

Business, industry, parks, nature settings, government infrastructure, and people, can be invaluable resources for connecting STEM curriculum within context which results in conditions ideal for promoting purposeful learning of authentic STEM content. Thus, community-based STEM resources offer ideal context for teaching STEM content. A benefit of focusing teacher attention on these contextual, content aligned resources is that they are in every community; making place-based STEM education a possibility, regardless of the location of STEM teaching and learning. Further, associating STEM teaching and learning with local resources addresses workforce development and the STEM pipeline by exposing students to STEM careers and applications in their local communities.

The desire to align STEM teaching and learning with local STEM related resources guided the design of our week-long integrated STEM K-12 teacher professional development (PD) program, i-STEM. We have completed four years of our i-STEM PD program and have made place-based STEM a major emphasis of our curriculum. This report focuses on the data collected in the fourth year of our program. Our week-long i-STEM PD served over 425 educators last summer (2013), providing them with in depth theme-based integrated STEM short courses which were limited to an average of 15 participants and whole group plenary sessions focused around place-based integrated STEM, inquiry, engineering design, standards and practices of Common Core and 21st Century skills. This state wide PD was distributed in five Idaho community colleges and took place over two weeks.

The STEM short courses included topics on engineering for sustainability, using engineering to spark interest in STEM, municipal water systems, health, agriculture, food safety, mining, forestry, energy, and others. Integral to these short courses were field trips designed to connect the K-12 educators to the resources in their local communities that could be leveraged for teaching integrated STEM and provide a relevant context for teaching STEM content. Workplace presentations made by place-based STEM experts and provided teachers field trips to place-base STEM industries and business such as manufacturing plants, waste water treatment systems, mines, nature parks, food processing plants, research, hospitals, and laboratory facilities.

We researched the 425 participants' conceptions of place-based STEM prior to and after their taking part in the summer institutes, which included fieldtrips. Our findings revealed substantial increase in our participants' knowledge, interest, and plans to use place-based resources for teaching integrated STEM. We detail the data analysis and provide a theoretical foundation and justification for the importance of place-based STEM to address the STEM pipeline for the future workforce.

Review of Literature

Place-based learning

Place-based learning involves leveraging local opportunities, structures, experts, and features (e.g., the environment, civic attractions, science centers, industries, and businesses) to situate learning locally and provide context and reason for learning^{1,2}. The justification and research on place-based education have found support in environmental education²; however, there are also proponents of a place-based approach to address economic, cultural, and civic issues³. The rationale for a place-based approach to learning has been established on the notion that students will be more engaged in learning, develop deeper understanding of content, and retain knowledge to a great degree, when the content that they learn is connected to their local community and/or environment^{4,5,6}.

The integrated STEM focus in our K-12 educator professional development (PD) project has increased the importance of knowing the degree by which K-12 educators are leveraging place-based or community resources for teaching and learning STEM. The effectiveness of an integrated STEM approach is enhanced when teachers to think outside the classroom by considering use of place-based resources. Consistent with the work of others, we argue that when teachers become aware of the local resources and opportunities, and align those opportunities to the curriculum⁷, they can broaden the curriculum focus and more effectively integrate STEM content using the local resources as context for teaching and learning. A place-based curriculum necessitates teachers consider use of integrated content, greater levels of collaboration, and inclusion of community-based resources.^{2,7} In our examination of teachers' place-based STEM practices, we determined that there was rationale in gathering data to determine the extent to which teachers sought local opportunities, activities, people, experts, and resources for teaching STEM, and we posit that their place-based practices likely influence their consideration and implementation of an integrated STEM approach.

Although there has been research on place-based science education^{1,6} and environmental education⁷, we were not able to find any research focused on a place-based approach to teaching multiple areas of STEM or any that addressed integrated STEM. The lack of extant literature reporting studies of teacher engagement in place-based STEM suggests that there is a gap in the literature. The gap is accompanied with the challenge of effectively assessing teachers' place-based STEM practices. Although a range of approaches to assessing place-based practices have been explored⁶, there remains the challenge of ensuring that measures are consistent with the context and content focus under consideration. Thus, we maintain that free-response questions are most effective, particularly when seeking insight into teachers' perceptions and practices in a place-based integrated STEM context.

Teacher Professional Development in STEM

Most K-8 teacher preparation programs require their graduates to have completed two semesters of math, two semesters of science, and no engineering courses; leaving them with very limited preparation to teach integrated STEM content⁸. Further, secondary STEM teachers are unlikely to have had exposure to engineering as part of their preparation programs. A broad understanding of STEM is especially critical for elementary teachers who may be responsible for

teaching a range of STEM topics and concepts^{9,10}, as well as, secondary STEM teachers who may be expected to effectively teach an integrated STEM curriculum which includes engineering. The potential need to teach a broad range of STEM content and the predicted constrained preparation presents the justification for providing PD for K-12 teachers that is focused on enhancing their preparation to teach STEM. Further, the increasing presence of engineering in the K-12 STEM curriculum¹¹ provides the justification for also attending to these teachers' capacity to teach engineering related content. Thus, the constrained preparation and exposure to STEM content and the likelihood for the need to effectively teach a range of STEM concepts provided additional validation for our creation, implementation, and investigation of a PD program designed to use integrated STEM practices to enhance teacher capacity to teach STEM content in authentic STEM contexts.

Teacher PD can have both implicit and explicit goals, influencing an assortment of teacher content, pedagogical, and affective variables¹². The connection between teacher confidence and efficacy with their effectiveness^{13,14} and the possible relationship between content knowledge and teacher effectiveness^{15,16,17} provides warrant for attending to a wide range of variables in teacher PD.

We embraced the notion that attention to a wide range of variables is necessary to influence teacher effectiveness, enhance their practice, and continue their education. Thus, we structured our summer institute PD to attend to the teachers' affective states in relation to teaching STEM, their STEM content knowledge, engagement in place-based STEM, and STEM pedagogy. For example, our summer institute included 20-25 hour short-courses which explored a wide range of integrated STEM topics such as mining, space exploration, health and the human body, energy, robotics, and computer programming, to make the content relevant and engaging to the teachers in learning in ways that were intended to enhance their capacity, confidence, and desire to teach an array of STEM content. Further, each of the courses maintained a focus on local resources related to the STEM content areas of the short courses which also included field trips to local resources to connect the STEM learning with the place in which the STEM education is based.

STEM In the Local Community

Applications of knowledge of STEM is found in all communities. From construction, to healthcare, to pesticides, and to cooking; the need for and use of STEM knowledge is ubiquitous, and at the same time dependent on the contexts of location or industry while developing local resources for educators to draw from in the future. For example, the STEM knowledge needed for agriculture is likely to differ significantly from the STEM knowledge needed for energy production. Similarly, the STEM knowledge needed for robotics is likely to be very different than the STEM knowledge applied in mining. Regardless, how STEM knowledge is being applied in their local communities provides an excellent opportunity to assure purposeful learning of STEM¹⁸. Through the use of local STEM contexts, students learn authentic applications of STEM knowledge, gain insight into the necessity, and are exposed to relevant and engaging opportunities for learning STEM.

We embraced the place-based focus situation in our i-STEM summer institutes and included contextual-based fieldtrips tied to content taught in the strands for the participating educators to gain a deeper awareness of how STEM aligns with the STEM in their communities. The premise

of our effort was to increase the contexts and potential applications that educators might use to teach STEM. Our goal was to bring greater alignment between the STEM that is taking place in schools and the STEM that is taking place outside of schools. Thus, we were seeking a means of providing the participants with the knowledge and resources needed to allow them to easily move about across a broad STEM spectrum in their curriculum and instruction.

Method

We used the following questions to guide our research:

- *What is the STEM focus and structure in schools and the STEM focus and structure in the local community?*
- *Who in the local community is engaging in STEM education, how are they engaging, and what is the outcome?*
- *How is educator involvement with place-based STEM related to their comfort with teaching STEM, engagement in STEM education, and STEM education leadership?*

We predicted that the teachers participating in our summer institute would have limited engagement in place-based STEM, and the STEM in schools would not be aligned with the STEM in the community. We also predicted that our i-STEM PD program would increase the participating teachers' comfort, engagement, and leadership in STEM education.

Participants

The participants in our study were the 340 individuals that completed both our pre and post institute survey out of 425 who attended the five summer institutes in 2013. The average age of the participants was 43.65 years ($SD = 9.92$) and the average length of teaching was 13.13 years ($SD = 8.57$). Elementary teachers made up 48% of the participants, while middle school/junior high teachers were 37% of our participants, and high school teachers were 15% of the participants. Females were 81% of the participants, and Caucasian non-Hispanic were 96%. Forty four percent of the educators were from urban areas, 42% were from sub-urban areas, and 14% were from rural environments. The majority of the participants had taken four or less science courses (63%) and four or less mathematics courses (66%). The participants had an average level of comfort with STEM teaching and learning.

Measures

We administered several surveys to the participants prior to their attending our 2013 PD program and again after the program to determine how our focus on integrated STEM and place-based STEM influenced a wide range of variables and impact on teachers. Our instruments were a combination of extant and generated tools that we adapted and adopted to focus on integrated and place-based STEM.

Demographics. We developed a demographic survey using standard items of age, highest degree attained, year of teaching, endorsements, current employment position, and sex. We included items to determine engagement in and nature of other STEM PD. We also included an item asking participants to rate their comfort with teaching STEM on a scale of 1 (Very Uncomfortable) to 10 (Very Comfortable). Our demographic measure was consistent with those commonly used in research on PD programs.

Engagement in STEM Teaching. To assess our participants' level of engagement in teaching STEM and the nature of the engagement, we developed the A-TEST, the Assessment of Teacher Engagement in STEM Teaching¹⁸. The original instrument development was based on over 300 teachers' responses to free response items asking them how they engaged in STEM teaching. We have examined the exploratory factor analysis and item content and refined the instrument to 22 items with responses similar to a 5 point Likert-like scale. The original A-TEST has 47 items distributed among eight sub-scales that we collapsed to 22 items and four subscales which included influence in STEM teaching decisions, collaboration with others for STEM education, STEM instructional practices, and teacher STEM PD. The composite scores were interpreted with a value below "3" as below average engagement in activities that promote STEM learning, a "3" being average level of engagement in STEM learning activities, and a response above "3" being actively engaged in activities that promote STEM learning.

Leadership in Education. We adopted and adapted the instrument that was developed by Posner and Kouzes¹⁹ to focus on teacher leadership in STEM teaching and learning. For example, we transformed the item "I seek out challenging opportunities that test my own skills and abilities." to read, "I seek out challenging opportunities that test my own skills and abilities in STEM." We retained the original instrument 10 point Likert-like scale, and maintained the number of items at 30. The scale ranged from 1 representing "Almost Never" to 10 representing "Almost Always." The authors of the original scale reported the reliability with a Cronbach's alpha of .98 and a test-retest reliability of .96. Posner and Kouzes¹⁹ suggest interpreting outcomes such that low composite values represent rarely or never involved in leadership, a value in the middle value representing sometimes involved in leadership behavior, and a higher value representing fairly often to frequently involved in leadership as portrayed in the instrument.

Place-Based STEM Teaching. To assess our participants place-based STEM practices, we developed an instrument that contained a combination of selected and free response items. It is important to note that since our work was exploratory and pioneering, we had limited support from the literature and researchers to guide our work. Thus, we considered our approach to be an initial exploration into place-based STEM which afforded us with liberties in our methods for gathering data regarding teacher knowledge and engagement in place-based STEM.

To gather data to determine how and to what extent our participants engaged in place-based STEM curriculum development, instruction, and collaboration, we developed items such as "Who in your community is the most instrumental in advocating student STEM learning?", "What kind of relationships exist between your community and school in regards to STEM education?". Our long term goal was to use the responses to this pilot survey to develop a selected response instrument to assess K-12 teachers' place-based STEM practices. We vetted our items with faculty and researchers familiar with the practices associated with place-based learning. Based on their feedback, we made small modifications to the language of our instrument, but retained the initial content and emphases.

The i-STEM Summer Institutes

Our 2013 i-STEM summer institute program activities included a combination approaches to

providing PD to the over 425 participating K-12 educators and maintained a focus on place-based *integrated STEM*. The goal of our intensive four-day residential summer institute was to build capacity in STEM content, 21st Century skills, leadership, pedagogical knowledge, design, and awareness of place-based resources for 425 participating educators who voluntarily registered for and participated in the institutes. Our institutes provided about 40-45 hours of direct contact time, 20 of which were dedicated to learning STEM content in *strands*. Each strand had 15-20 participants who enroll in one of 28 short courses developed around integrated regional STEM content (e.g., wind energy, robotics, space, agriculture, forestry, health, aerospace, food safety, mining processes, and others) in context associated with place-based resources, and included business and industry partners. The *strand* providers were part of the annual competition to be part of the program. The annual competition for developing and presenting strands ensures ongoing relevance, adherence to state learning standards and practices, and quality PD. Selected strand providers submitted a syllabus, lesson plans, alignment to STEM learning standards and practices, and material lists for a classroom “kit” of up to \$250 of supplies required to implement their curriculum for each of the strand participants. The supplies were provided to *each* strand participant using additional funding provided by business and industry. The strand providers also submitted a content/subject knowledge test aligned with the STEM concepts taught in their strands, which were vetted, modified for clarity, and used to pre and post-test their participants.

The i-STEM strands focused on integrated STEM and included elements of scientific inquiry, engineering design, mathematical modeling, 21st Century skills ²¹, hands-on/minds-on learning, design principles, applications of technology, authentic applications of STEM, and practices of the state and national STEM learning standards. The strand curriculum was taught by modeling best instructional practices including lab activities, independent projects, research activities, content related field trips, assessments, and presentations. Each participant was expected to create an integrated STEM lesson idea (a mini lesson or unit plan based on a template we provided) to attend to the learning standards for each of the separate STEM domains.

The place-based integrated STEM theme was addressed throughout all plenary and whole institute activities. The remaining 15-20 hours of the i-STEM summer institute time included presentations by renowned keynote speakers who discuss and explore a range of STEM education and learning topics. Topics included elements of comparing engineering design to scientific inquiry, implementing project-based learning, critical thinking throughout the curriculum, using hands-on/minds-on materials in instruction, embedding 21st Century skills in instruction, developing STEM career awareness, assessing learning of students engaged in design activities, and how engineering design takes place in STEM business and industry. Part of the remaining time was allocated to allow participants to spend time experiencing STEM in place-based workforce settings and developing and planning family/community STEM events.

Data Conditioning

Following data collection, we conditioned the data using the functions in SPSS such as replacing missing values in responses (if 2 or less were missing in response) using the mean response replacement option, and we reverse coded the Likert scale responses to the reversed phased items. We matched the participants’ pre and post test scores based on the unique last five digit of a phone number code they provided and used demographic information in cases of duplicate

codes to match scores. Once completed we calculated composite mean scores for our quantitative measures which we used for our analysis.

We organized our quantitative data based on the content focus, the quality, and the detail of the responses. The organization allowed for ease of coding and efficiency in exposing trends in responses. Further, the coding also allowed us to effectively conduct a mixed methods approach in our analyses.

Results

The examination of our data began with an analysis of the qualitative responses to our survey items which asked our participants to detail the nature of STEM in their communities. We used a combination of inductive and deductive codings in a content analysis²⁰ to expose the trends and activities as detailed by the participations.

In addition to the coding of the qualitative data we calculated the reliability of our quantitative measures. Our engagement in STEM education measure had a Cronbach's Alpha of .93; our leadership in STEM measure had a Cronbach's Alpha of .97; our measure of perception; knowledge of the Common Core State Standards Math had a Cronbach's Alpha of .91; and our quantitative items on our measure of place-based STEM had a Cronbach's Alpha of .87, indicating that all of our measures had high levels of reliability. The high levels of reliability indicated that we could proceed with our analyses by means of assurance that our measures were statistically reliable.

STEM Structure. Our first research question asked: *What is the STEM focus and structure in schools and the STEM focus in the local community?* To answer this question, we examined the responses to our items asking our participants about the nature and structure of STEM education in their schools and in their local community. We first examined the responses to our selected response item that allowed the participants to select from a list of the STEM domains that are focused on in schools and the STEM domains that are of primary focus in the local community (see Figure 1). Our analysis revealed a notable disparity between the STEM focus in schools (dominated by mathematics) and the STEM that takes place in the local communities (dominated by agriculture). Our results suggest that the kinds of STEM activities taking place in schools are not consistent with the STEM taking place in the local communities and in the local workplace.

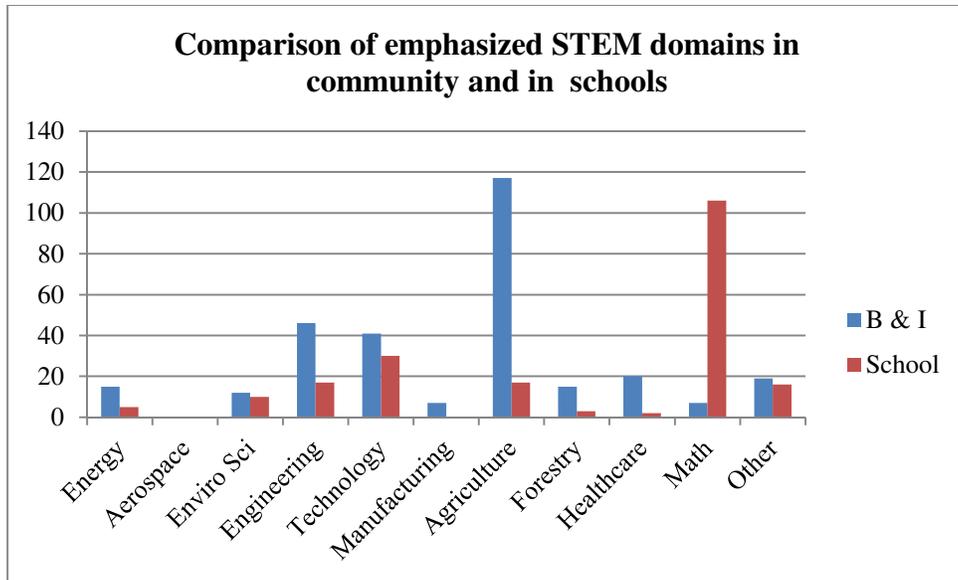


Figure 1. The responses to the STEM foci in schools and in the local businesses and industry.

We next examined how our participants indicated that their STEM curriculum was structured based on their responses to an open-end item. We sought these data to determine if the participants had the flexibility and support needed to shift toward a more place-based oriented curriculum. We coded the responses into categories that included none, rigid, flexible, some organization structure, and depends on the situation in the schools. Our results suggest that there is sufficient flexibility in the STEM structure to allow for shifts in the STEM foci and practices of the participants to develop and maintain a place-based STEM emphasis (see Figure 2).

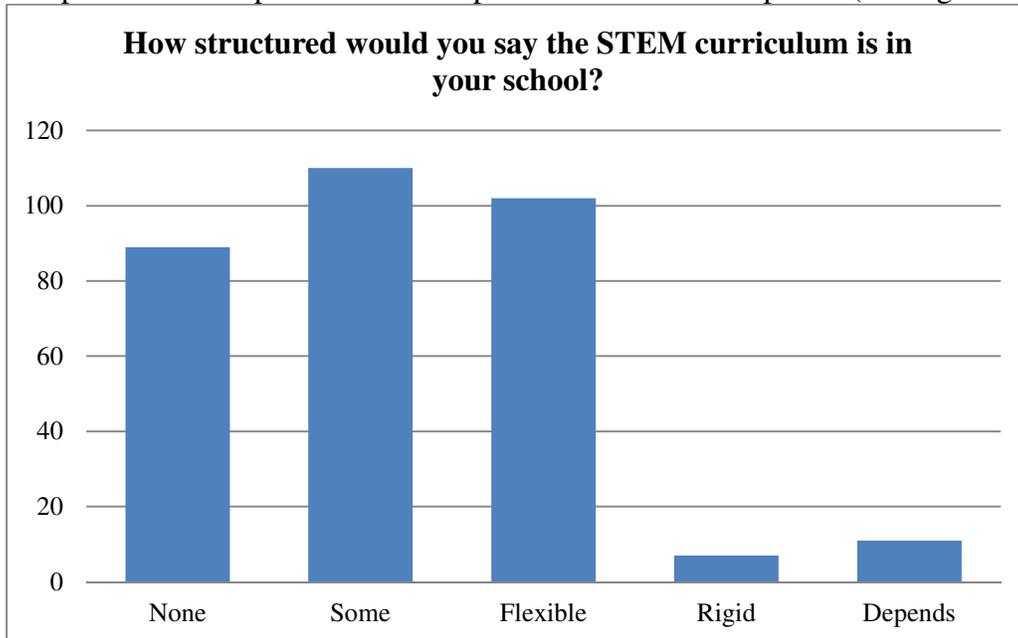


Figure 2. Structure of STEM curriculum in participants' schools.

We continued our analysis by examining the responses to our open ended items, asking our participants to share how they are engaged in place-based STEM teaching (see Figure 3). We

coded the items into the 7 dominate groups that emerged from the content analysis. Our analysis indicated that integration with other subjects dominated how our participants engaged in place-based STEM teaching. Other major ways the participants indicated that they engaged in place-based STEM teaching through project based or inquiry based projects. Many indicated that they deferred to the math or science teachers to be responsible for place-based STEM teaching. Overall, our results indicated that place-based STEM teaching is not a high priority for our participants and they were not actively seeking innovative or creative ways to support place-based STEM teaching and learning.

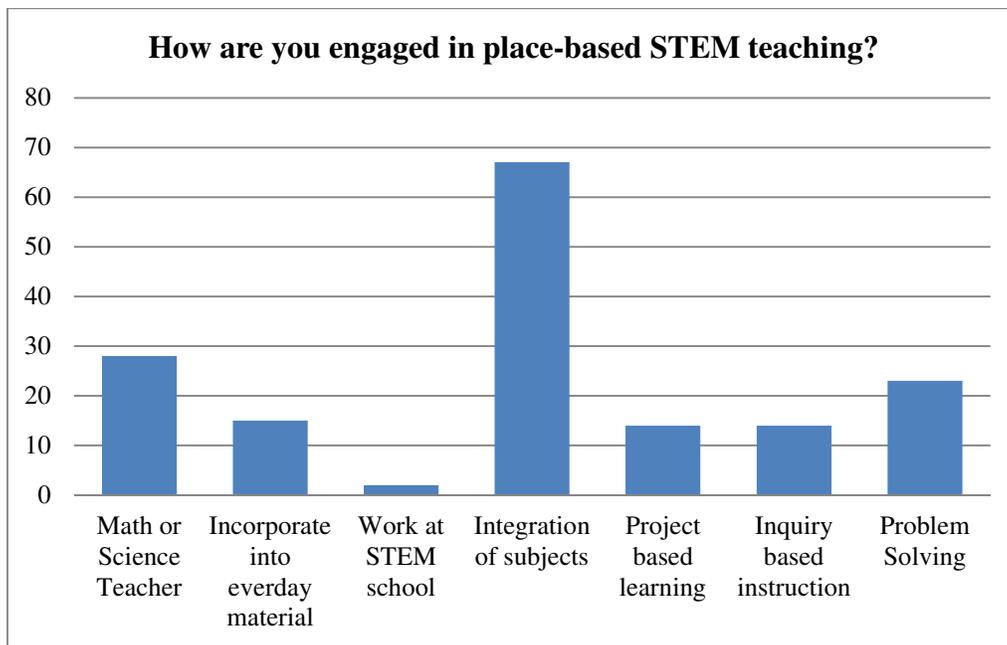


Figure 3: How teachers are engaging in place-based STEM teaching.

STEM and Local Community Engagement. Our second research question asked: *Who in the local community is engaging in STEM education, how are they engaging, and what is the outcome?* To answer this question we examined the replies to our selected and free response items asking our participants about their engagement with community members in STEM education.

To gain a greater understanding of the key STEM education agents in our participants' communities, we examined their responses to a selected response item asking them to indicate who the promoters of STEM education are in their communities. The results were dominated by educators, in particular teachers and administrators (see Figure 4). Others promoters of STEM education included people from business and industry, as well as, groups such as STEM committees or STEM teams.

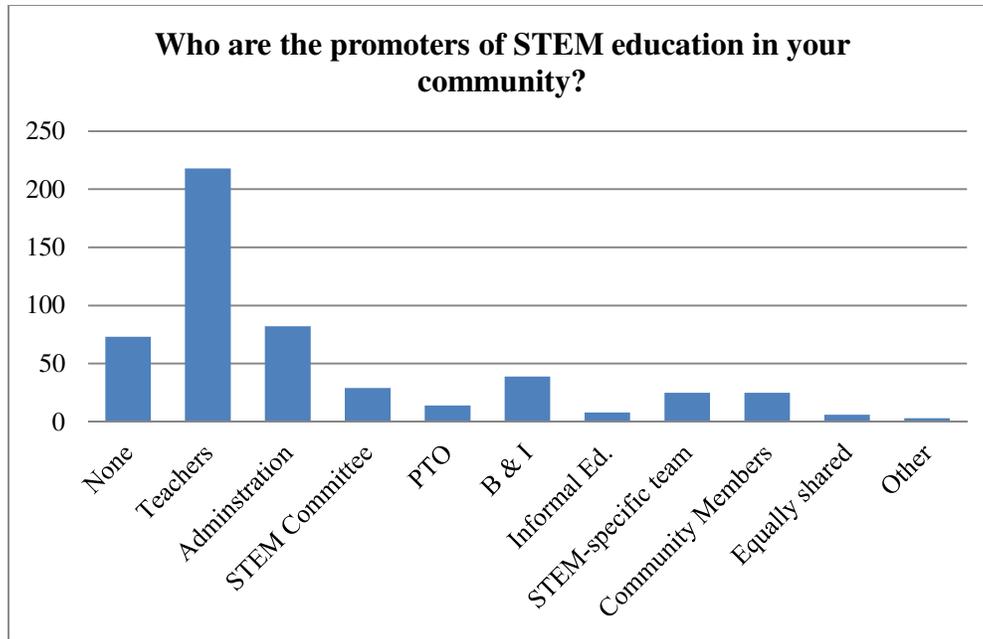


Figure 4. The promoters of STEM education in the local community.

Building on our research in the area of the promoters of STEM, we sought to gain insight into the advocates for STEM education, which we determined by examining our participants' responses to our item asking them (using a list in a selected response item) to share who in their community was most instrumental in advocating student STEM learning (see Figure 5). Teachers dominated the responses, indicating a perception that others in the community are not likely involved in advocating for STEM in a manner that would support an emphasis on place-based STEM.

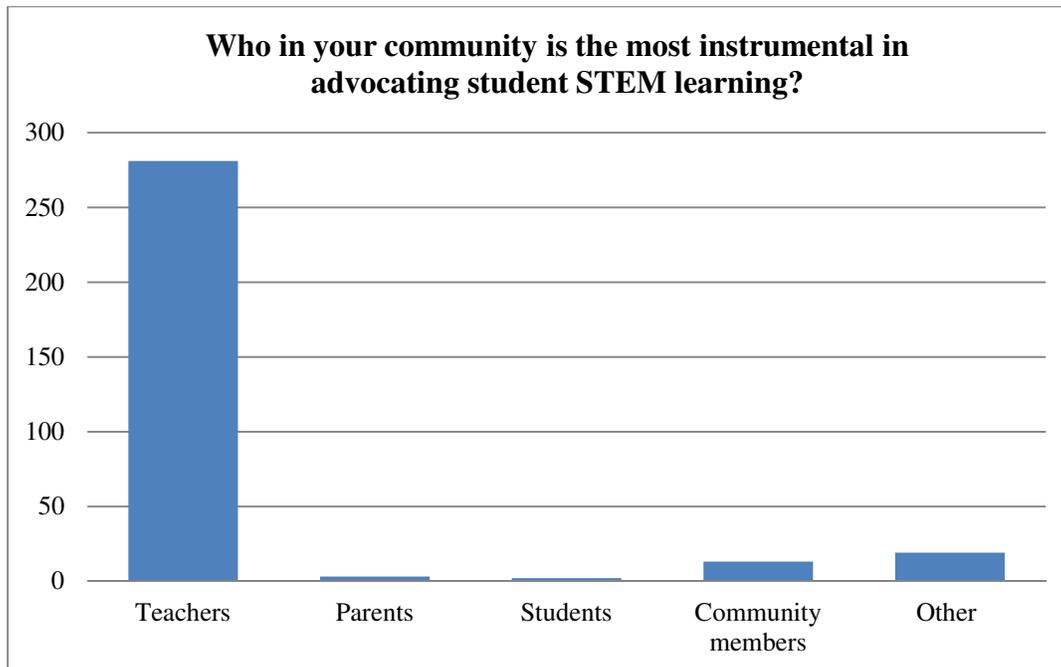


Figure 5. Who in the community is most instrumental for advocating for STEM learning.

We examined replies to the free-responses item that asked the participants to share the relationship between the school and local community with regard to STEM teaching and learning. We were readily able to group the responses into four general categories. The responses suggested that there was none to some interactions to support STEM learning, with school-to-school dominating the configuration of the interactions (see Figure 6). The responses suggest the there is a lack of collaboration around STEM teaching and learning in the communities, which may hinder opportunities for teaching place-based STEM.

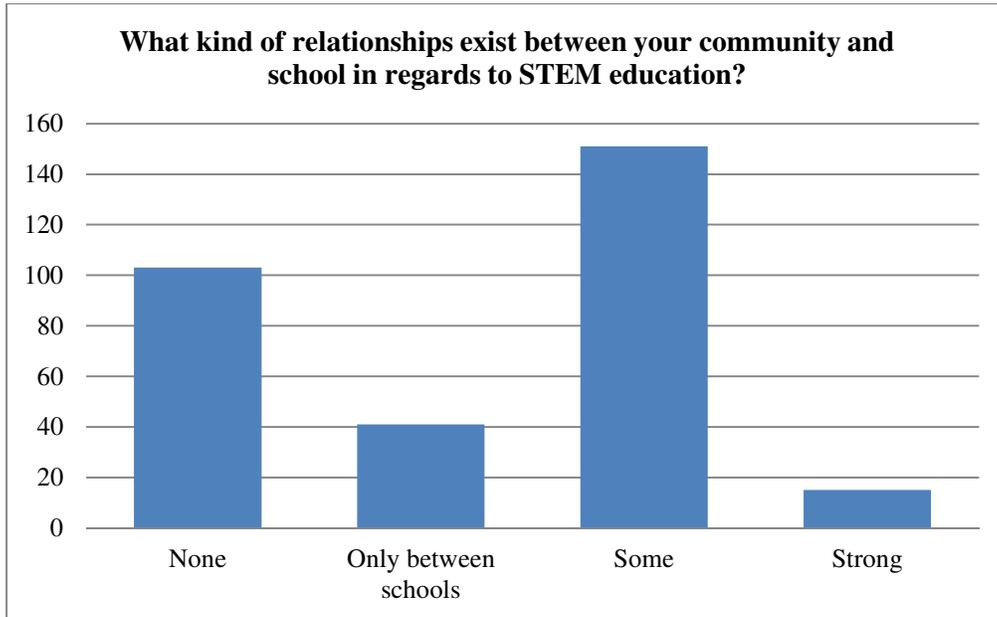


Figure 6. The relationships supporting STEM education in the local community.

To gain further insight into the nature of the relationships we asked the participants to share how long these relationships have existed (see Figure 7). The responses indicated none to short term (0-3 years) dominated the duration of the relationships. The results suggest that many relationships or collaborations focused on STEM education are in early stages, thus indicating multiple opportunities for developing relationships, as many indicated that no relationships existed.

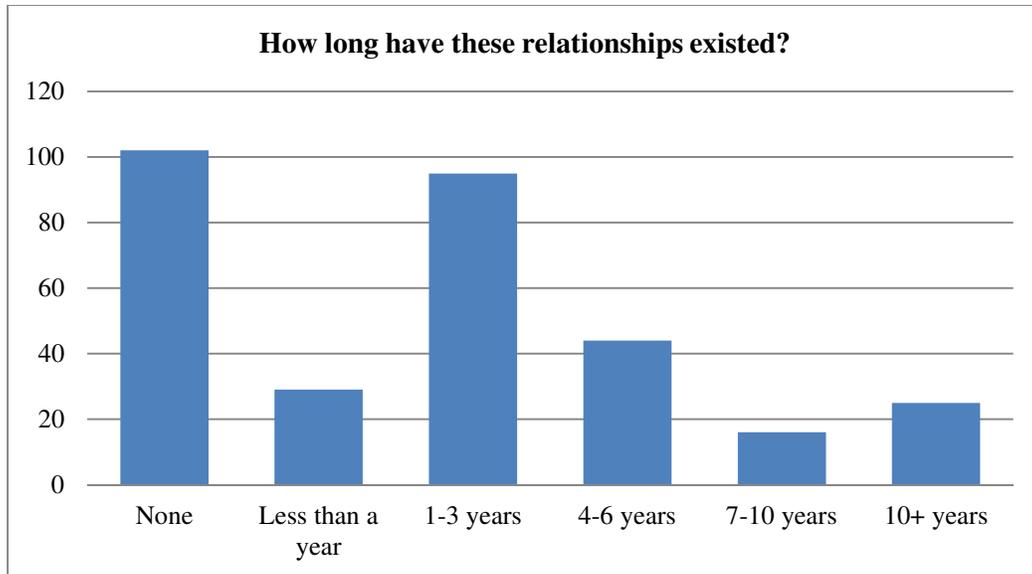


Figure 7. The length of the relationships supporting STEM education.

To determine who took responsibility for the connections between schools and the community, we examined our participants' responses to our item focused on STEM education relationship leadership (a selected response question). Our analysis revealed a wide range of stakeholders are taking responsibility for the relationships with teachers and administrators dominating the leadership (see Figure 8). The wide range of stakeholders suggests that there are likely opportunities for shared responsibility.

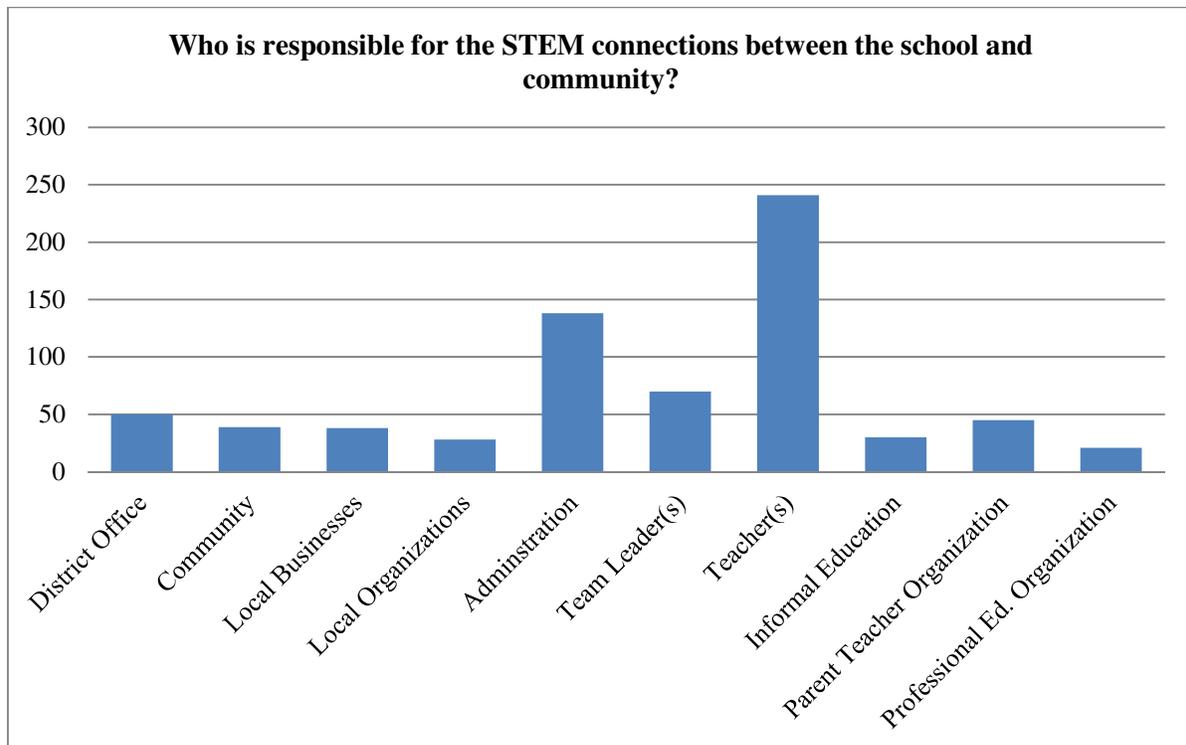


Figure 8. Participants' responses to who is connecting STEM in schools and community.

To gain a deeper understanding of the STEM education focused relationships between schools and the community, we asked our participants to reply to a free responses item detailing how opportunities for community involvement in STEM were structured. Our analysis revealed little to no structure dominates opportunities for community involvement (see Figure 9). Our results suggest there is a need to develop more formal structures for community involvement in STEM teaching and learning.

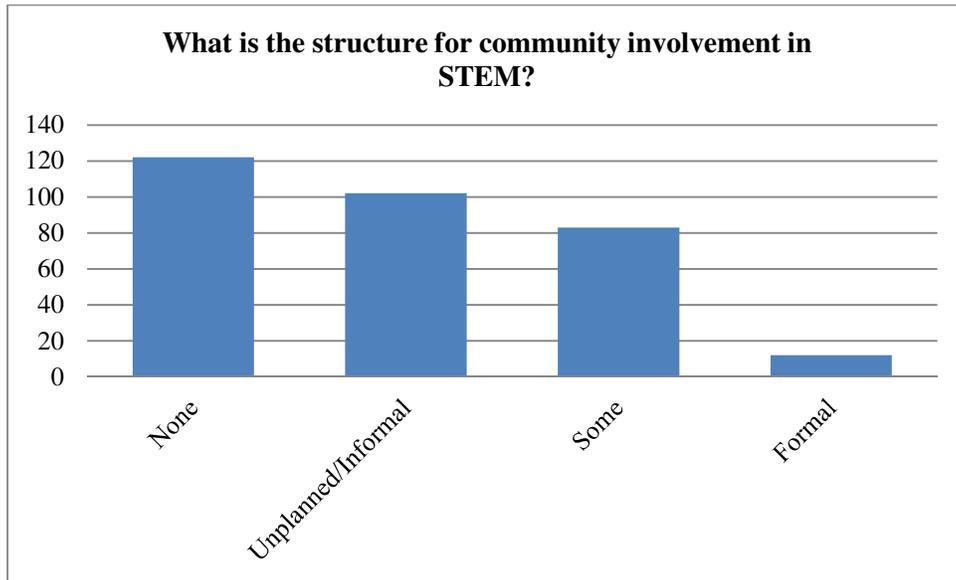


Figure 9. The structure of STEM community involvement.

We next examined the replies to the free response item asking the participants to share the impact of community involvement in STEM learning. Our analysis revealed those who answered other than none indicated higher levels of teacher and student involvement with the community, and increased student enthusiasm for learning, or a generally positive outcome (see Figure 10). Our results suggest that when community is involved in STEM learning, there are benefits in higher levels of engagement for students and teachers.

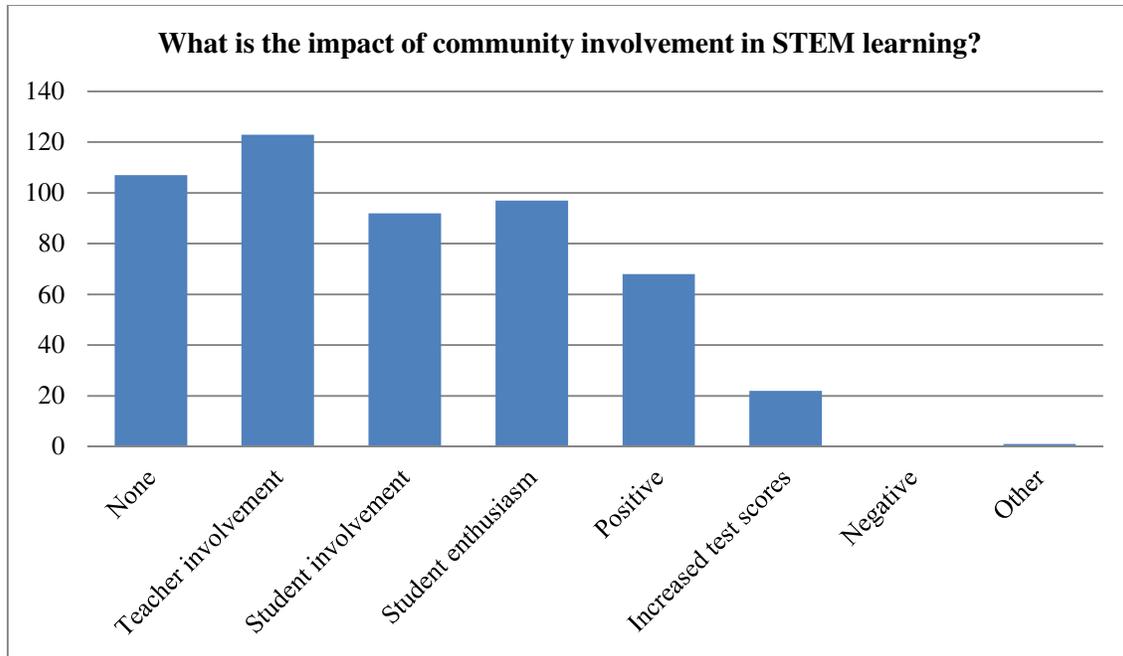


Figure 10. How community involvement has impacted STEM learning?

Our desire to determine how adults are involved in supporting STEM education led us to ask our participants to share, through a free response question, the capacities in which adults in their communities engage in supporting STEM learning. Our analysis revealed that most adults are involved as guest speakers or in field trips (see Figure 11). However, the responses also indicated a wide range of capacities, suggesting that there are variations and potential opportunities for involvement that could influence place-based STEM.

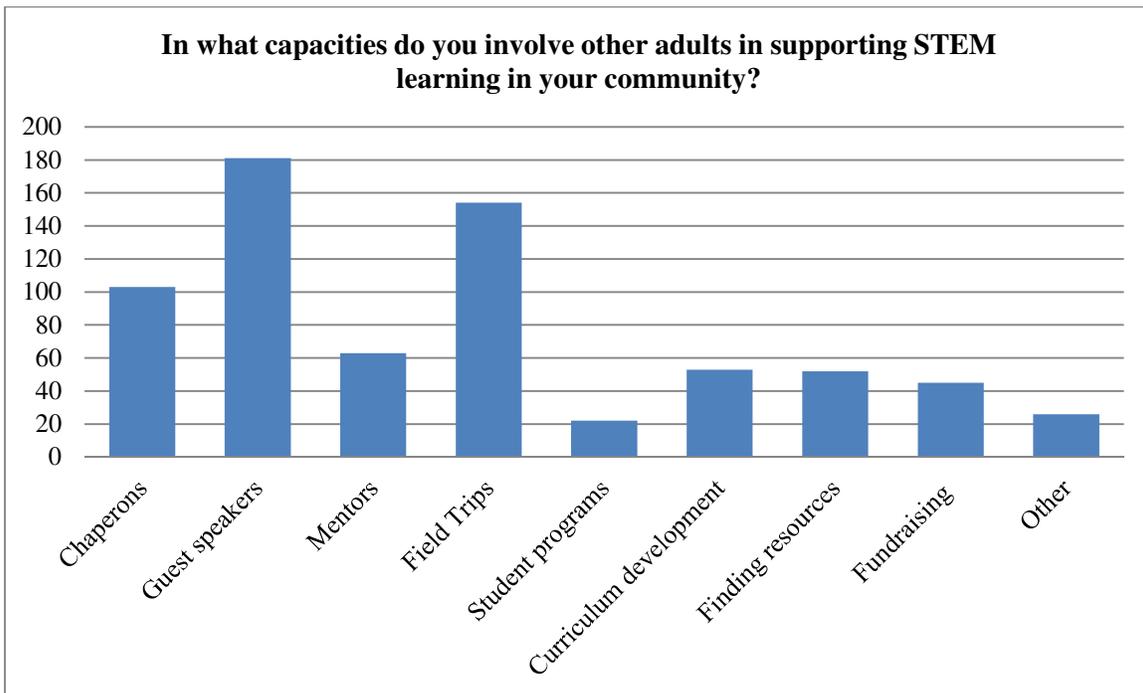


Figure 11. How adults in the community are engaged in STEM learning?

The next free response item we examined, asked our participants to share the results of the STEM education collaborations with the community. Our analysis revealed that none dominated the responses; however, those who provided other answers indicated a wide range of opportunities (see Figure 12). The wide range of responses suggests that there are multiple options to establish or expand place-based STEM learning opportunities.

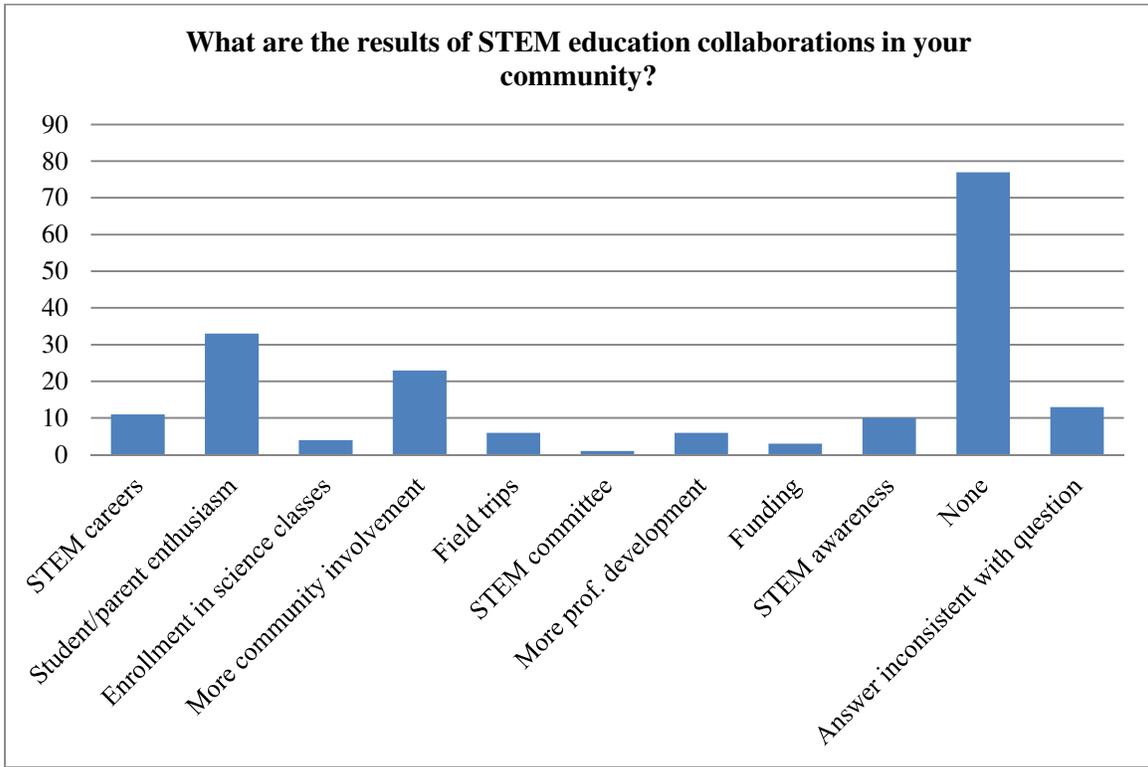


Figure 12. Results of STEM collaborations.

Relationship of Place-based STEM to STEM Education Engagement. Our third research question asked *How is educator involvement with place-based STEM teaching related to their comfort with teaching STEM, engagement in STEM education, and STEM education leadership?* To answer this question we conducted a correlation analysis of the average participant scores to our measures of place-based STEM teaching, knowledge of the CCSS-M, leadership in STEM education, engagement in STEM education, and comfort with teaching STEM (see Table 1).

Table 1

The Correlation between Engagement in Place-based STEM and other Measures of Involvement in STEM Education.

	Place-based STEM Teaching	Knowledge and Perceptions of the CCSS-M	Leadership in STEM Education	Engagement in STEM Education	Comfort Teaching STEM
Place-based STEM Teaching	--	.226*	.432**	.587**	.233**
Knowledge and Perceptions of the CCSS-M		--	.247**	.294**	.140
Leadership in STEM Education			--	.736**	.486**
Engagement in STEM Education				--	.533**
Comfort Teaching STEM					--

* $p < .05$, ** $p < .01$

Our calculations revealed significant relationships between place-based STEM teaching and engagement in STEM teaching, leadership in STEM education, knowledge and perceptions of the Common Core State Standards – Mathematics, and comfort of teaching STEM. We interpret our results to indicate that educators who are engaged in place-base STEM teaching are also more likely to be involved in leadership in STEM, engaged in a wide range STEM education activities, have higher levels of comfort with teaching STEM, and hold more positive attitudes and greater knowledge of the CCSS-M.

Discussion

Place-based learning holds much potential for increasing student engagement in learning STEM by making the content purposeful, relevant, applicable, and motivational, contextualizing leading within the local environment. Further, the focus on place-based STEM in education aligns STEM learning with the STEM found in the local workplace, businesses, and industries. Realizing the educational benefits and the potential to address the STEM workforce pipeline development, we developed our 2013 i-STEM summer PD institute to focus on STEM learning opportunities in the local community. However, as we planned our implementation, it was apparent that there was a need to gather more information about how educators are engage in place-based STEM education and the nature of community involvement STEM learning, and the characteristics of educators in relationship to their engagement in place-based STEM. We

responded to this need and integrated the research on place-based STEM as part of our summer institute.

Our research has revealed that STEM in schools and STEM in the community are misaligned, which may significantly constrain the conditions necessary to create meaningful place-based STEM learning opportunities. We maintain that there is a need to align the STEM with the workplace to increase the STEM pipeline and student preparation for STEM careers, which would make place-based STEM learning more meaningful and natural. We posit that such alignment can occur through STEM PD that incorporates place-based resources and local STEM experts.

In terms of the structure of STEM education and teacher engagement in STEM teaching, we found there was relatively wide-spread flexibility in the curriculum, and teachers tended to engage in a wide variety of STEM teaching activities. Given the latitude that teachers have in their STEM curriculum, and the range of possible ways that teachers engage in to teach place-based STEM, there are many possibilities that are not being leveraged. We maintain that capitalizing on the flexibility and range of STEM teaching activities could lead to greater opportunities for place-based STEM learning, thus creating a relevant and engaging content for STEM teaching and learning.

Our analysis of leadership, promotion, and structure of community involvement in place-based STEM learning, revealed teachers and administrators are the primary leaders in STEM education. Yet, there was also a variety of others also identified who are engaged promoters of STEM education in the community. We also found that our participants indicated that a wide range of place-based STEM learning activities were taking place. We assert that more efforts need to be taking place by teachers and administrators to involve community members in STEM learning. Further, the range of activities for STEM learning could be distributed more equitably and developed to have a place-based focus. Increasing involvement of other community members and leveraging existing STEM learning activities to have a place-based focus could expand the opportunities and strengthen place-based STEM learning.

Our analysis of the characteristics of participants indicated relationships between leadership in STEM education, engagement in STEM education, comfort with teaching STEM, and knowledge and perceptions of Common Core State Standards – Mathematics, with engagement in place-based STEM learning are common characteristics that continue to need attended to and addressed in STEM PD for K-12 teachers. These relationships suggest that STEM PD should address multiple aspects of place-based STEM to enhance the capacity of teachers and administrators.

Limitations

Our research is based on the self-report of our participants, therefore, we are limited to the information that our participants choose to share. However, the combination of the quantitative and qualitative data allowed us to triangulate our findings, which were consistent. Future research may use an interview or focus group approach to gain a deeper understanding of our findings.

A second limitation of our research is associated with our interpretation of the data. Although we were conducting a content analysis using codings to expose trends, we may have inferred the meaning of the participants' responses. However, the consistency in responses and in the trends we exposed suggested that our interpretation was accurate. Again, future research using interviews or focus groups may help substantiate our findings.

Our third limitation was the cross-sectional method we used to gather our data. Although our research was intended to help establish a baseline for place-based STEM teaching and learning, it is limited to a point in time and does not provide insight into the long term development of place-based STEM. We have plans to follow-up with our summer institute participants to determine the long-term effect of our PD on their engagement in place-based STEM.

Conclusion

Place-based learning has great potential in STEM education and has long term benefits. However, our research revealed that there is a lack of place-based education taking place in STEM teaching. Our research also revealed there is tremendous potential for developing place-based STEM by leveraging existing structures and opportunities. Professional development offerings may be key to the short and long term development of place-based STEM. Our ongoing research and STEM education PD are key to promoting and monitoring the progress of place-based STEM teaching and learning.

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