Where do We Go from Here? Conversations with K-6 Principals Following Three Years of Engineering Education Professional Development for Their Faculty

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Abstract

Preparing elementary level teachers to teach engineering as part of their curriculum is fundamental to meeting the goals of the Next Generation Science (and Engineering) Standards, and for addressing the professional engineering pipeline. To address the NGSS goals and pipeline we engaged teachers from six elementary schools in summer workshops over a three-year period with ongoing school year professional development and support to enhance their understanding and integration of engineering concepts and content in teaching and learning.

The results of our professional development efforts\(^1,2,3,4,5\) revealed substantial increases in the teachers’ knowledge and implementation of engineering lessons with their students. We documented increases in the scope and depth of lessons, and shifts in the level of design control from the teachers to the students indicating a shift in faculty role from deliverer of information to facilitator of learning.

At the conclusion of our three-year initiative, we embarked on a study to investigate the impact of the project on the culture of the school, the nature of interactions between teachers, and future directions for STEM related professional development particularly associated with engineering. To do this, we developed an interview protocol and contacted the principals in each of the six schools and scheduled time to talk with these school leaders.

The responses of principals revealed numerous effects associated with the whole-school approach to implementing inquiry-based learning of STEM (science, technology, engineering and mathematics) subjects using BrickLabs\(^\text{TM}\) as a teaching tool. Positive effects were noted concerning increased student engagement, enhanced parent interactions and the principals expressed appreciation for the project and a desire for its continuation. Overwhelmingly, the most notable and possibly legacy-level impact occurred in teachers, as a result of the professional development in combination with the ongoing support of mentors and the whole-school approach. Teachers benefited from increased common experiences, enhanced communication, the presence of mentors, acquisition of inquiry based learning techniques, increased camaraderie, increased collaboration, increased cross-curricular activities and more. Across the board, principals reported what amounted to there being in essence a school culture shift, with teachers being more open to new ideas and a significantly increased level of collaboration.
Introduction

Using the extant literature, our experience, and the needs communicated by the K-12 teacher community in our region, we identified a number of cognitive, affective and pedagogical variables and used them as a guide to develop and refine a STEM professional development project that is now complete, termed “The SySTEMic Solution.” The SySTEMic Solution was a three year project involving teachers from six elementary schools; details and results from this project are presented elsewhere. The primary goal of the project was to enhance the capacity of elementary teachers to understand and teach engineering to their students.

Our SySTEMic Solution professional development project was unique for several reasons. First, our initiatives and professional development project was a collaboration between a college of engineering, a college of education, and an instructional materials vendor. Second, our project emphasized both the development and teaching engineering lessons, focused on both content and pedagogy at the K-6 level. Third, the project included extensive follow-up visits to participants’ classroom, observations of lessons, and instructional feedback to the teachers. Fourth, our project took a whole school approach in the six participating elementary schools, seeking to promote systemic STEM education change, using engineering as a context. Fifth, as part of our project, we gathered a wide range of data to determine the characteristics, perceptions, opinions, and knowledge of our participants regarding integrated STEM, and used the information over the three years of the professional development in iterative processes of improvement.

Our current report details the follow-up research that we conducted through interviews of the principals in the six participating elementary schools. We were seeking to gain insight into the long-term influence of our program on the STEM culture, STEM curriculum, STEM instruction, and STEM professional development in the buildings.

Before we present our research we provide some background to justify the emphasis on elementary schools for enhancing STEM education. We also provide some support for investigating the views of school administrators as a critical process for gaining insight into the culture, needs, and possibilities for systemically addressing STEM education.

STEM in the Elementary Curriculum

There are increasing expectations that citizens engage in STEM and in particular, engineering related discussions and decisions on topics such as energy, food, transportation, and information technology. To meet expectations of public involvement in STEM related decisions there is a need to assure citizens have fundamental understanding of STEM concepts. People begin to develop perceptions and knowledge of STEM prior to and during their elementary education, which increases the importance of teaching STEM, particularly engineering at the elementary level. Further, capitalizing on young learners’ innate interest in engineering at the elementary level can stimulate their desire to later learn more about STEM. The potential gains and influence of quality engineering curriculum and instruction at the elementary level provides justification for supporting efforts to increase elementary teachers’ capacity to teach engineering. In addition to the direct influence of teachers on student development of STEM knowledge, there is a secondary influence of school administrators, as they are likely to influence their teachers’ capacity to provide progressive and sustained STEM curriculum and instruction.
The effective teaching of engineering content in the elementary curriculum moves beyond assuring an informed citizenry; it is also crucial for meeting the tremendous demand for STEM professionals. Exposing young learners to the work of engineering professionals and the related occupations is essential for increasing interest and knowledge of STEM careers, a process that relies on elementary school teachers. We contend that to increase elementary student awareness and understanding of engineering careers requires teachers to be well acquainted with engineering content, pedagogy, and workforce needs and developments. The increases in inservice teachers’ engineering content, pedagogy, and workforce needs are likely to be directly influenced by school leadership, such as principals. School principals have influence on the context and prioritization of the professional development offerings for teachers and therefore influence on teachers’ ongoing development of expertise.

Teaching engineering requires a broad knowledge of both the content and pedagogy necessary to help students learn. For example, without prompting or encouragement, young learners will naturally develop and hold STEM related conceptions and misconceptions. Young learners’ development of misconceptions can interfere with the acquisition of additional knowledge. The development and influence of STEM-related misconceptions may be rectified if addressed early. However, for elementary teachers to be effective at addressing STEM misconceptions they must hold accurate knowledge of STEM concepts and be prepared to effectively teach the related content. Gaining content and pedagogy knowledge requires ongoing professional development and support, conditions that school principals influence. The potential for the high levels of influence on sustained professional development of teachers to enhance their effectiveness for teaching STEM provides justification for the examination of the priorities, perceptions, and plans of principals with regard to STEM professional development.

Elementary students rely on their teachers for the acquisition of accurate STEM content and development of foundational STEM knowledge provides motivation for assuring elementary teachers are provided opportunities to continue their development of STEM understanding. We structured a three summer institute to provide such opportunities to elementary educators in six elementary schools by specifically and explicitly addressing their content knowledge and pedagogy in engineering. Our research indicated that our professional development influenced the teachers; yet, we wondered about the influence on the general STEM culture and environment of the schools. Of particular interest was how principals perceived our summer institute influenced the STEM education culture, focus, and needs of the teachers.

Elementary Teacher Preparation in STEM

The typical elementary education teacher certification curriculum requires candidates to complete two college level science courses and two college level mathematics courses and no engineering courses, which is arguably incomplete preparation for teaching STEM curriculum. To overcome the limitations associated with minimal preparation in STEM it is essential that teachers engage in continuing education. Thus, professional development in STEM is critical for assuring teachers are prepared to effectively meet the engineering education needs of their students. Since principals play a critical role in the professional development of teachers, it is important to determine how principals are
influencing the engineering related professional development offerings and supporting opportunities in their schools.

The shift in K-12 STEM curriculum from being organized around specific academic disciplines to an emphasis on themes or big ideas (NRC, 2011) requires teachers to have more of a system perspective and broad STEM content knowledge. It is unlikely that without considerable continuing education K-5 teachers can be prepared to effectively teach STEM curriculum around themes. An integral component of teaching STEM curriculum is providing opportunities for students to engage in inquiry, design, authentic applications, and active learning environments, which likely requires teachers to seek ongoing professional development. While professional development in STEM curriculum and instruction can take many forms ranging from brief seminars to university courses and degree programs, there is a consistent expectation that we document the effectiveness of these programs. In our project we attended to this expectation and examined the impact at the school level by interviewing principals in the schools. Further, we used the interviews as an opportunity to gain insight into future STEM related professional development needs of the schools.

Yet, even as the quality of STEM education is being addressed, the quantity of STEM related curriculum at the elementary level has experienced a steady decline. The reduction may be attributed to reform mandates that emphasize student achievement of mathematics and language arts skills. However, it may also be possible that the reduction is reflective of teacher preparedness and curriculum choices. Because most teachers are inclined to teach what they were taught, teachers may not eagerly embrace the idea of teaching STEM content due to confined preparation to teach STEM. However, as Levitt reports, when provided with useful models, teachers tend to be open to modifications in their teaching. School administrators may be critical for addressing teachers’ development that may lead to increases in the quantity and quality of the STEM education they teach.

**Leadership and STEM Implementation**

Leadership can tremendously impact teacher engagement in professional development addressing curriculum, instructional, and content. As Desimone, Smith, and Phillips report, authority (such as a principal) influences teachers’ engagement in professional development. Further, principals can have a secondary influence on teacher engagement by fostering a work environment that leads to low staff turnover, a condition that Desimone and colleagues also report as influential on teacher engagement in professional development. Thus, in our situation, the promotion of STEM as a school priority, and the subsequent support of opportunities for teachers to engage in STEM professional development is key to continuing to enhancing the capacity of teachers to effectively teach STEM and more specifically engineering.

The leadership of a principal is influenced by their values. Thus, if a principal finds value in STEM, and values the preparation of students around STEM themes to effectively engage in STEM workforce development and societal issues, they are likely to make STEM a priority in their leadership. Law et al., report that the behaviors of principals are guided by their values and lead to actions that are aligned with their values as they perceive situations and problem solve. We maintain that principals who value STEM will find creative ways to support STEM education by developing agendas and opportunities to engage teachers in professional development and other professional activities that further STEM.
New models of school leadership reflect a more collaborative approach to making decision and supporting curriculum in schools that include principals, teachers, and other stakeholders\textsuperscript{40}. Principals’ influence in both the supervisory and instructional domains is strongly related to that of teachers’ active participation in decision making, suggesting the benefits of mutuality in school leadership\textsuperscript{41}. We contend that effective STEM programs require principals to be actively involved in STEM education decision making and involve teachers and other stakeholders in discussion and choices associated with STEM curriculum, instruction, and related activities.

**Methods**

We interviewed the principals in six elementary schools involved in our three-year engineering focused professional development project to determine if there were perceivable shifts in STEM education in the schools. We were also interested in gaining insight into the future needs of the schools to inform our next generation of program development. Thus, we sought to expose data that would allow us to gain insight into the influence of our program on the school environment, academic choices, and STEM related other programs offered in the schools. We used the following question to guide our research:

- *What were the principals’ knowledge of, perceptions of, and future plans for STEM education in their schools?*

We hypothesized that the principals would be highly engaged, supporting the creation of STEM focused learning environment, and would be actively seeking STEM professional development opportunities for their teachers.

**Participants**

Given our sample and the potential for identification of individual participants and a commitment to the respect for and compliance with guidelines for working with human subjects, we are reporting very general information about our participants. We maintain that the general information is sufficient for readers to understand our participants without compromising the concealment of our participants’ identities.

The participants in our program were the principals of the six schools involved in our three-year professional development program. The principals had worked in the schools for as short as a semester to many years. Further, they had varying amounts of experience as principals that ranged from less than one year to more than ten years. Some had extensive STEM background while others had little or no formal preparation in STEM.

Our work took place in ten different schools, over a period of four years. During the project teachers in 118 classrooms received the *Bricklab\textsuperscript{TM}* manipulatives and developed a range of STEM lessons to use the instruction materials. Over the course of the project about 2700 children used the manipulatives to learn STEM and other subjects, with the content limited only by the creativity of the teachers involved in the project.

**Data Collection**
To guide our data collection we developed a series of interview prompts. We based the prompts on our desire to determine the lasting impact of our three-year project, the current state of STEM education in the schools, and the future STEM-focus professional development needs of the schools. Our intention was to use the interview prompts for some level of consistency of data collection among the participants, yet, maintaining the options to have more of a conversation about STEM education in the schools. Thus, our final data collection process was a combination of asking a series of a priori interview prompts and the interjection of spontaneous questions to gather additional information or bring clarity to topics, events, or ideas shared by the participants.

Procedure

Our data collection began with arranging a one-hour long appointment with each participant. Although we anticipated our interviews would be shorter than one hour we wanted the flexibility in our time to allow for longer conversations if necessary. At the appointments we greeted the principals, shared with them our research goals, provided them with a consent form and had them sign a copy of the form to allow us to record the interview. We then took turns reading the prompts and asking the principals to reply. If the principals replied with ideas, events, or plans that needed clarification or led to another direction of STEM education development, we would follow with a clarifying prompt. At the end of the interview we asked the principals to share some final thoughts and provide additional information about their earlier responses. The interviews were about 30 minutes long. Once we had completed all of the interviews we had the recordings transcribed for analysis.

Analysis

In analyzing the responses of the principals, we consolidated some of the responses, as information relevant to one question was sometimes provided in a response to a different question. Overall, we used a content analysis approach to our analysis, seeking to extract the consistent trends among the participants’ responses. We used a combination of extant codes and emergent coding, as we anticipated some responses and were open-minded to the consideration of an array of other responses.

Results

The following section summarizes the principals’ responses to the interview questions.

Involvement in PD. In response to Q1, “How are you involved in your teachers’ professional development in STEM?” we received a range of general comments (see Appendix 1). Nearly all the principals (5/6) described a district-level requirement of weekly collaboration time, which was inherently tied in with professional development and that seemed in general to be very beneficial to the school, particularly given the nature of this project, which provided a base level of professional development on inquiry-based learning. The collaboration time appears to have helped facilitate collaborative activities (also see responses to our interview question 2) and a roaming district-level science curriculum leader was able to use the collaboration time to help teachers envision how science could be integrated with other aspects of the curriculum such as reading and writing. Four of the principals described their role as a facilitator or encouraging force in terms of professional development. For example, Principal 2 (P2) indicated, “I am more of a facilitator (guide on the side) than the person doing the staff development.” Money and time were mentioned as issues by half of the principals; the
professional development days in this district were at an all-time low as a result of budget cuts. Two principals expressed a need for more professional development for their teachers.

**Teaching Practice.** In response to Q2, “How has your faculty involvement with BrickLab™/SySTEMic Solution influenced their teaching practice?” there were several overarching responses of note. P2 remarked: “The BrickLab™ experience helped teachers to realize, through participation, what project-based learning could be, should be. What it looks like, what it feels like so that they were more comfortable implementing that into their classrooms.” P4 noted, on teachers who use the BrickLab™: “The kids get so involved and interested in it; it captivates them and intrinsically motivates them to want to do this…this is in contrast with what I have observed when a teacher is just lecturing and the kids are just bored.” P6 observed, “[My teachers are] more collaborative, and more creative.” He/she described how inquiry based learning is necessary when you use BrickLab™, as “It's just a tub of bricks … as a teacher you are going to have to use some inquiry based learning to figure out what to do with that and in addition your kids are going to do the same.”

In addition to the overarching responses, four of the principals commented specifically on the cross-curricular nature of using BrickLab™. For example, P3: “They [teachers] are realizing that they can actually be teaching reading while they are teaching science and where math can come into play.” Three commented on the fact that BrickLab™ is appropriate at all ability levels in their schools, for example, P5 remarked: “It was great to have one thing that everyone could be a part of. It didn't matter if it was a student that had a 130 IQ or a student who was diagnosed with a physical limitation, everyone could be involved no matter what their academic abilities are and I think that is great.” There were also two comments that related to how the whole school approach to this professional development project produced ancillary benefits such as increased teaming and communication among the faculty.

**Student Learning.** Principals were asked in Q3, “How has Bricklabs/SySTEMic solution influenced student learning?” Most of the principals called out two aspects in particular. The first of these, concerned how the BrickLab™/SySTEMic solution project engaged students with their learning. An example quotation, from P4: “…the way the kids light up and the way they construct things and they are teaching themselves and teaching others and telling me things that I would not have been able to get from them with a paper and pencil…” P6 noted: "It has built interest, I mean; those kids are excited about it! So, [we are] building interest in science and building interest in learning and making sure that they come to school ready to do it. They are excited about that when they get here." The second aspect called out by most of the principals concerning integrated or cross-curricular learning, which was also described in responses to Q2. P1 noted, “It is a way to integrate writing with (math, science, engineering).” Not all teachers were comfortable with integrating STEM learning with other disciplines; P5 noted that the degree of integrated learning depended on the individual faculty member’s interest and comfort level in STEM. Several principals mentioned standardized test scores and achievement measure scoring in response to this question. Three of the six principals brought up inquiry based learning in their responses. For example, P2 indicated that the BrickLab™/SySTEMic solution project “Seems to help students really understand what they are doing (and transfer knowledge);” while P1 noted, “With all the basic skills that are being taught in elementary, adding inquiry to it is a ‘mind shift,’ requiring reflection, time and coaching.”

**Support STEM.** The fourth interview question asked: “What are some ways you promote or support STEM teaching with your teachers here?” There were several general responses; P6 indicated that
he/she: encourages science to be integrated into the other subjects (rather than teaching science every Thursday from 2 to 3). Encourages science to be open-ended -- an opportunity for scientific inquiry as opposed to content acquisition. P3 promotes incorporating STEM into the new common core -- getting teachers to think through how incorporating STEM would play out in a project or in a classroom on a daily basis -- "where I want to get to is that whole inquiry based learning." P2 noted that his/her school (a STEM focused school) had hired a hired staff member whose job was to teach engineering, who serves as a resource to the teachers -- the in-house expert (an engineer formerly employed by a large engineering firm).

At some point in the interviews, the subject of technology was discussed by all principals. The remarks concerning technology are summarized under question 4. Comments ranged from concerns – P1: “We grapple, struggle with technology/technology a limiting factor,” and P4, who several times noted his/her faculty having a “fear of technology;” to praise of their schools (P3 and P5) in terms of the classroom technology present. One principal, P2 noted that he/she was “Concerned with getting technology for the sake of spending money and getting technology without building need and foundational support behind it: "Instruction and curriculum should drive what the technology needs are; we shouldn't buy technology and then find a need for it." Of note -- that principal’s entire school was already equipped with document cameras and projectors.

**Preparation to Teach STEM.** Our fifth interview question asked, “How would you classify or describe your faculty's preparation to teach science/STEM?” Responses to this question were grouped into three general categories. The first category centered around: variability of preparation in terms of content; and variability in terms of being able to integrate science with other subject areas. For example, P4 noted: “How science is taught varies significantly, depending on the teacher. "I know there are some that do what they need to and as soon as it is done, they move on. Others [who perhaps are more prepared to, or interested in science] find ways to incorporate science and reading together to get it intertwined.” P6 remarked: The (science) knowledge that they come into in the profession is minimal at best… "I would say it's true of anything that teachers that really enjoy it [science] have more content knowledge behind it without a doubt."

The second category of responses by principals to Q5 concerned variability of implementation/authentic teacher buy-in. There were three responses from principals in this general category. One remarked (P2) that his/her school, a STEM focused school, had full “buy-in,” and noted that he/she had personally hired all the staff and communicated the school vision at that time, which effectively ensured buy-in. P5 noted: “Some of the teachers grab on and want to do it [Bricklabs™] next year, and some are "like I don't have time to do this.” P6 observed: “I think it has been a bigger change [referring to teaching practices] to those that have really embraced it for the process and not for the [free] credit. Realistically speaking, some only took it because they needed credits and there wasn't a charge for them to participate in the credits, but those who really went at it ...I have seen a huge turnaround.” One principal (P3) remarked on a legacy effect, indicating that his/her teachers are rebounding from "No Child Left Behind," which "almost put us in a box of 'this is reading and this is my reading book.'" P3 went on to add that his staff members were just beginning to grow a cross-curricular capacity.

The third category of responses to Q5 concerned confidence. P1 noted that his/her faculty is strong in science, but lack confidence in it; and that training is needed to bolster confidence in their ability to teach science. P4 referred again to an element of “fear” in terms of the way he/she summarized how
teachers respond to tying engineering into the curriculum. P4 also noted that teaming helped increase teacher confidence.

**Whole School Approach.** The next question, Q6, asked: “Has there been a benefit from the whole school approach from BrickLab™/SySTEMic project?” There was a very rich range of responses to this question, with numerous categories and multiple responses in each category. Overwhelmingly, fun/camaraderie was brought up in response to this question – both among teachers and among students. “We realized through the SySTEMic project [that kids] respond well to science. Kids really enjoy that.”

Common experiences among faculty were described as a benefit as well as the common vocabulary and language used by teachers and students in terms of BrickLab™. Continuity between grades was mentioned as a benefit, and P6 remarked: “It was introduced in fourth grade last year and now in fifth grade they already know the rules of they bricks, they already know how to prepare and store them, they know why we have them in our classrooms that they are not just for free play but there is a purpose.”

Parents were mentioned by four of the principals – P2 remarked that it assured some consistency within grades, helping eliminate parent preferences (“I want that teacher because they do engineering and the other one doesn’t.”). P5 noted, “I have had some parents come in and tell me about things that their kids have done with their Legos at home and … it is not just this toy they have at home, they can also do multiplication, they can say, "look what we did in class." The parents say, "Wow, it's not just a toy, it is an instructional tool." In terms of involvement in a whole-school STEM challenge, which most recently involved building a “Green City,” P4 noted: “I don't think that will be going away. The students really drove that, they built it, they completed it, and they got Mom and Dad to attend. It was packed; there was no room in the gym. The first thing they did was go over to the tables to look at the cities the kids had built.”

There were numerous compliments about the project. P2 noted, “You should be very pleased with the outcomes of this project; thank you.” “It was motivational, the teachers loved it….the implementation aspect was done well -- the way that teachers were forced to implement it.” P6 explained that he/she was going to continue to use Bricklab™: “We will continue with the SySTEMic project just because it's great for kids and it brings them in, especially with kids that are resistant learners. In addition, Legos are expensive. My population cannot afford them. So with my population of kids this is their first time to mess with them and that is how it is. This is an opportunity for them, it is an opportunity for them to go home and say we did something cool in school today...That is what SySTEMic has allowed us to do.”

There were numerous remarks – the most in any category – made by principals concerning there being a school culture shift, and there being increased collaboration between teachers (beyond what they had normally seen), see Appendix A (in two rows, under Q6). Remarks by principals made elsewhere in the interviews were consolidated in this area. P1 remarked, “It's a complete shift in how you plan” – “that cross-curricular thing is kind of a lifestyle and it's a complete change of thinking on how teachers plan.” P2 and P6 remarked on how this was made possible (a school culture shift) as a result of the project being school-wide. P3 noted that teachers are more open to new ideas (as a result of being in this project). "I can tell you just from being in other buildings, it is easier for me to go to them with my ideas." "I can already see the flexibility and the openness for ideas that they have." P3 also observed that he/she had seen how the inquiry method had crossed over from using strictly Bricklabs™ in their teaching into other media (using tape to construct objects for an inquiry exercise). P5 mentioned collaboration: “where you can sit down and collaborate with a grade level and say I want to use bricks
for this concept and let’s think of a way that can work. I think it has caused a shift in culture just because it is something familiar that they all have used.” Appendix A contains additional responses.

**Mentors.** The seventh interview question asked about mentors: “How have the mentors influenced teacher practice and teacher development in developing STEM related instructional practices?” Responses indicated that mentors helped with communication, with helping teachers meet deadlines; that they were an effective sounding board for ideas and were supportive; that having someone on site made the difference in terms of whether staff would follow through with the project. One principal (P6) pointed out an advantage of having mentors to them in their role as principal: “The mentor is the one "selling" it to teachers -- not the principal -- which is different, as she is one of them.” The importance of having in-school mentors in terms of the project’s success in terms of how it effectively implemented inquiry based learning across the school is summarized in P5’s comment: “I think that if we didn't have the mentors encouraging, demonstrating and being example of what they could do, I think the only time the Bricks would come out would be when someone was coming to observe what they had going in a lesson.”

**Next Generation Project.** The last interview question, Q8, asked, “What ideas do you have for a next generation of project?” Responses included ideas for continuing or improving the current project – having even more follow-up throughout the year; getting feedback from the users who were still reluctant to embrace inquiry-based learning; and just simply continuing the project while teachers continued to professionally grow. Several principals had suggestions in terms of scheduling; however, there was no consensus among the responses as to what sort of schedule would work for all schools (whether a one or two-day long workshop in summer, or conducted in smaller segments throughout the year, etc.). Several principals commented to really work to get “authentic teacher buy-in,” in any future project.

There were a number of miscellaneous suggestions, see Appendix A, some mentioning incorporating technology (e.g. robotics), one mentioning having access to an expert, and one mentioning a “train-the-teacher” model. P6’s responses were particularly thoughtful: “If there is some way we can incorporate social responsibility into science with something like creating green schools or awards for green schools.” (see Appendix A for more); and, “Create an academic system where kids receive what they need at the level in which they need it. We have that in math and reading -- incorporating science into that would be fantastic.”

**Discussion**

The discussion below is based on the results from the interview questions. We summarize the findings from each question, posit potential explanations, and present some associated implications for our findings.

**Involvement in Professional Development:** Our research revealed that the ways principals were involved in their faculty members’ professional development ranged widely across the board. Although limited by budget and time, principals were generally supportive and described themselves as helping facilitate (STEM) professional development. Two principals outlined a highly collaborative approach, involving teams with participants from the various grade levels that determine goals for the year, consistent with certain new models of school leadership 36. All of the principals appeared to value
STEM and professional development and exhibited appreciation for the project and the professional development that had been provided to their teachers. We posit the variations in principals’ involvement is due to a combination of their knowledge of STEM, the value they place on STEM, and their vision for the usefulness of STEM for engaging and motivating student learning.

**Teaching Practice.** The principals indicated that they perceived that faculty involvement with BrickLab™/SySTEMic Solution influenced teaching practice by helping teachers to realize, through participation, how to effectively implement project-based instruction. As one principal noted, the open-ended nature of an enormous tub full of bricks lends itself to an inquiry, hands-on approach in terms of student learning. Thus, there was general agreement that the summer institutes and sustained academic year activities (development of four lesson plans and several classroom observations) of the SySTEMic Solution project provided teachers with professional development in inquiry based teaching and learning. The principals’ responses indicate that our project pushed the horizon of teaching practices of the teachers in six schools to engage in inquiry and active learning environments – both integral components of teaching STEM\(^{20,21}\). The data also suggest that a combination of rather brief, yet intensive professional development events can have notable influence on teacher practice.

**Student Learning.** In response to being asked how the SySTEMic solution project had influenced student learning, principals responded that they noticed increases in student engagement. In addition, principals noted that there was an enhanced degree of integrated or cross-curricular learning. A possible outcome of the enhanced ability of teachers to integrate STEM in a cross-curricular way with reading and writing may be to slow or stop the decline in the quantity of STEM related curriculum that the elementary levels have been experiencing\(^{18}\). We also speculate that the models that the teachers were exposed to and engaged in during the summer institutes were readily adopted and easily transferred to classroom practice.

**Support STEM.** Principals were generally supportive of STEM teaching, although there was no consensus in terms of the ways that they promoted STEM, apart from general encouragement. Instructional technology as a general topic was discussed in some fashion by all principals, ranging from concerns/fears regarding technology, to appreciation of upgrades their school had in terms of technology. All principals appeared to value STEM and appreciate the increased student engagement and preparation resulting from implementation of inquiry-based learning with BrickLab™. Thus, there is high potential that these principals will find ways to continue to make STEM a priority in their schools\(^{35}\). However, our data also indicate that principals are likely to adopt or promote professional development programs offered by others rather than developing and offering programs internally.

**Preparation to Teach STEM.** The principals in our study noted that their teachers had variable preparation levels in STEM; that their ability to integrate STEM with other subject areas varied among their faculty and that how STEM was taught varied amongst instructors. Principals also noted that there was variability among their teachers in terms of “buy-in,” or authentic participation. Finally, the issue of confidence level in faculty members was mentioned by several principals, referring to how some of their faculty lacked confidence in STEM subject matter. It is clear that ongoing professional development in STEM is warranted, even in schools that have had focused STEM professional development for multiple years. The data also suggest that a one-size-fits-all approach to professional development is likely to meet the needs of only a portion of participants. Therefore, professional
development offerings should be structured in a way to meet the needs of teachers with a wide range of capacities.

**Whole School Approach.** The responses of the principals indicate that the whole school approach resulted in enhanced camaraderie among their faculty, with increased communication about teaching STEM, inquiry-based learning, and cross-curricular activities. The project received numerous compliments from principals; some of those remarks concerned increased parental engagement. There was a strong consensus across remarks made by all principals that there had been a shift in school culture and also greatly increased collaboration between teachers. Overall, the project appeared to support a “useful model” for helping teachers to make modifications in their teaching, as there was wide (but not uniform) adoption of new practices. Our data suggest that whole school approaches to professional development can have profound impact on the culture of the school and associated community.

**Mentors:** The remarks that principals made about mentors revealed how mentors were crucial to the project’s ability to build a cadre of trained teachers who can carry out inquiry-based learning. In-school mentors were available for drop-in questions; they were effective communicators; they encouraged use of Bricklabs™ and inquiry and were supportive. We posit that peers as “project drivers” made the difference in terms of whether the project was authentically implemented, or whether lesson plans were just hastily put together for the sake of getting the credit for completing the course. Our results indicate that mentors can have a profound impact on changing the culture, practice, and learning taking place in a school. Thus, including mentors as part of professional development projects, arguably instructional leaders, is critical to the success of whole-school approaches and on-going support of teacher reflection and implementation of new STEM curriculum and instruction.

**Next Generation Project:** Overall, the project although seemingly quite effective at bringing inquiry based learning as an approach to whole schools, ultimately did not achieve full adoption – meaning that, from the principals’ perspective, 100% of teachers in the school did not fully buy-in to authentic implementation of inquiry based learning. Although a number of suggestions were made by principals in terms of scheduling options for professional development, the only consensus among principals that emerged from this question was a general desire to see the existing project continue in some capacity. These results further support our speculation that principals are not likely to lead the development and implementation of STEM professional development, and are more likely to seek and adopt professional development that is created and offered by others. Thus, although we were hoping to receive explicit insight into the STEM professional development needs of the principals’ teachers, we are instead challenged to assemble data and interpret results to determine the form and focus for the next generation of STEM professional development we embark upon.
Summary

The whole-school approach to implementing inquiry-based learning of STEM subjects using BrickLabs appeared to have made a significant and possibly legacy-level impact on the six elementary schools that this project focused on. Based on interviews of principals there is evidence to indicate that faculty benefited from the common professional development experiences, the presence of mentors, and the exposure and engagement in inquiry based instructional approaches, which led to enhanced communication, increased camaraderie, increased collaboration, increased cross-curricular activities and greater community involvement in STEM education. Our data indicate that students across multiple grades benefited from the teachers’ learning which led to the students being more engaged as a result of more hands-on STEM opportunities. Students also, benefited from the continuity of the Bricklabs™ as a teaching tool. We found that a whole school approach provided an opportunity for a school-wide competition that provided an excellent opportunity for students to share their work with parents. Across the board, principals reported what amounted to there being in essence a school culture shift, with teachers being more open to new ideas and a significantly increased level of collaboration. Our results indicate that a wide range of STEM education needs can be met with a properly structured professional development program.

Acknowledgements

The Idaho SySTEMic Solution was supported by a grant from the U.S. Department of Education Fund for Improvement of Education Program, award # U215100034. However, the contents of this paper do not necessarily represent the policy of the Department of Education, and you should not assume endorsement by the Federal Government.

Website with Lessons and Videos

This is the URL to a SySTEMic Solution website that includes teacher generated lesson plans and videos of classroom lessons –

https://sites.google.com/a/boisestate.edu/idaho-systemic-lesson-plans/home
References


Appendix
<table>
<thead>
<tr>
<th><strong>Principal 1</strong></th>
<th><strong>Principal 2</strong></th>
<th><strong>Principal 3:</strong></th>
<th><strong>Principal 4:</strong></th>
<th><strong>Principal #5.</strong></th>
<th><strong>Principal #6</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Q1: How are you involved in your teacher's professional development in STEM?</strong></td>
<td>Influenced by available, local thrusts (NTI &amp; Bricklab) with an overarching emphasis on science.</td>
<td>Clear, internal plan presented that involves a team with participants from the various grade levels that help determine goals for the year and then there is resource allocation.</td>
<td>She observes classes doing their projects, and has as a goal moving toward project based learning and supporting that. (??)</td>
<td>Clear, internal plan presented</td>
<td>Emphasis this year is on improving instructional strategies -- not focused on STEM but on general strategies.</td>
</tr>
<tr>
<td><strong>Collaboration mentioned (apparently a requirement of the district).</strong></td>
<td>&quot;we had our science person from the district curriculum person and come do some mini lessons that show how we can take our science curriculum and tie it to a lot of different other things and we did this during our Wednesday collaboration time.&quot;</td>
<td>Team environment - - not teachers in isolation: The middle school &quot;collaborates&quot; every Wed. -- so the engineering staff person collaborates with the Language Arts teachers and do technical writing and technical reading within the Engineering class.</td>
<td>Weekly &quot;collaboration&quot; for 40 mins; 7 groups and one is &quot;on duty&quot;. Reviews team norms, team goals, and then any needs (communications, discipline); And, there are in-services days, around 3 in total; during that time they focus on data, collecting data and on what is coming up. In addition, there is a once a month faculty meeting.</td>
<td>Weekly collaboration (required by district every Wednesday).</td>
<td>Coordinates training opportunities; vertical collaboration once a month for an hour for every grade level; set-aside time for them to work on SySTEMic.</td>
</tr>
<tr>
<td><strong>Facilitator/encourager</strong></td>
<td>&quot;As administrator I see my job as trying to figure out how to make it work within the limited parameters we have.&quot;</td>
<td>I am more of a facilitator (guide on the side) than the person doing the staff development. I did that at first, when our school was young, and everyone was new. As this school has matured, my philosophy is to build capacity of others within the building so that the professional development aspect continues if I ever leave. [Distributed leadership model].</td>
<td>I am meeting with them and empowering them to tell me more about how we could incorporate Bricklabs into all kinds of learning that they are doing all day.</td>
<td>This principal claims to be very involved; this collaboration aspect has been in place for three years.</td>
<td></td>
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</table>
### Money, time as an issue concerning professional development

- **Time is an issue.** Wants a way to pay teachers for Saturday morning or from 4 to 6 for prof. development, as he wants to keep the teachers in the classroom (and not buy their day out with a sub in order to do professional development). Also, "We have a lot less days than we have ever had in the past for professional development."

- **Budgeting was mentioned** "it is such a bad year but you would never know it in this building."

- **Mention of budget cuts which has reduced the professional development days; mention of being respectful of teachers' time when not on contract as so much is asked of them already."

### Cross-curricular learning mentioned

- **Cross-curricular is a thrust -- tying math and science in with reading, language and writing.**

- **"Part of the goal for this school was to provide project based learning activities for all the sciences within the school and to tie technical writing and technical reading into those."**

- **"Teachers are beginning to realize how they can actually be teaching reading while they are teaching science and where math can come into play."**

### Need for more prof. development

- **Feels there is a need for prof. development, although teachers don't ask for it.**

- **If there were a summer professional development opportunity, probably 90% of the faculty would participate.**

### Q2: How has your faculty involvement with Bricklab/SySTEMic Solution influenced their teaching practice?

#### Big picture answers

- **"Because it's an inquiry, you can do cross-curricular."** The Bricklab experience helped teachers to realize, through participation, what project-based learning could be, should be. What it looks like, what it feels like so that they were more comfortable implementing that into their classrooms.

- **It has helped develop conversations about how to integrate subjects with other subjects."**

- **His observations (paraphrased): On teachers who use the Bricklab; "The kids get so involved and interested in it; it captivates them and intrinsically motivates them to want to do this;" This is in contrast with what I have observed when a teacher is just lecturing and the kids are just bored.**

- **Their teaching practices have been "broadened": "It has really broadened their horizons;" they can see how using the bricks can really transform the students' understanding, so it has broadened their horizons in terms of "how can I incorporate this so I can get them to have something they can work on to show a concrete example of their task."

- **[My teachers are] more collaborative, and more creative. This principal described how inquiry based learning is necessary as "It's just a tub of bricks … As a teacher you are going to have to use some inquiry based learning to figure out what to do with that and in addition your kids are going to do the same thing."**

#### Cross-curricular

- **Bricklabs used in a cross-curricular way (math plus writing, for example); Cross-curricular is a thrust -- tying math and science in with reading, language and writing. "One of the third grade teachers was using**

- **The project-based learning experience helped teachers see how a math project can tie in technical writing and technical reading; Investigative practices have carried over into other areas of math and science.**

- **"They are realizing that they can actually be teaching reading while they are teaching science and where math can come into play."**

- **some teachers find ways to incorporate science and reading together.**
| Q3: How has Bricklabs/SySTEMic solution influenced student learning? |
| --- | --- | --- | --- |
| **Engages students** | It engages students. "You know sometimes you see a couple students were so wrapped up in their building you know that they were upset that they had to stop because they didn’t finish and that interfered a little bit with their writing!" | "I see a lot of students in groups, a lot of discussion -- it is kind of controlled chaos which is students talking to each other, which is not the same classrooms we’ve come from and grown up in where you sit in rows and "Seeing the way the kids light up and the way they construct things and they are teaching themselves and teaching others and telling me things that I would not have been able to get from them with a paper and pencil."

| **Team environment produced by this project helpful in other ways** | Used in special ed class because they were learning about simple machines. A Title 1 schoolwide title one. Many of our students need a lot of extra help -- interventions. | Commented that not every student will reach a certain target, but will be a different student at the end of the year. Mention of mixing ages of child as a result of their developmental level. | "It was great to have one thing that everyone could be a part of. It didn’t matter if it was a student that had a 130 IQ or a student who was diagnosed with a physical limitation, everyone could be involved no matter what their academic abilities are and I think that is great."

| **Because of the real teaming environment (as a result of the professional development),' the fear that they had in technology is going away because of communicating, teaming and supporting one another and it came through our Bricklab, building together, communicating those types of things..." Also: The staff is comitted, willing to work together, they communicate well, are respectful with one another and know how to take data. A good environment for an administrator or a staff member.** | Comment about "because it is a [school-wide]system, I can create time for [teachers] to sit down and collaborate. I can create professional development opportunities for them, and I can have a portion of the budget designated to that." |
| Integrated learning | It is a way to integrate writing with (math, science, engineering) | This is mentioned a few times (see other blocks) | In response to "how is science perceived here," "I think it is different depending on the class you look at. I know there is some that do what they need to and as soon as it is done they move on. Others find ways to incorporate science and reading together to try and get it intertwined." | there is direct professional development through SySTEMic to say "here is how you tie this into other subject areas"

| scoring; scores mentioned | We are Title I schoolwide. | Our students score at the top of the district even through we are not the top economic school in the district (we are about #10 on that list). | No child left behind mentioned. | one of the things we are low in is math understanding. This principal mentioned teachers collecting "data" a lot (in response to a new merit-based system just put in place).

| foundation; system | Bricklabs have provided a great foundation to build on. | "It has opened the way that they are looking at teaching and I can tell differences from other teachers especially in my role last year in the district at two different schools. You know how teachers get set on the way they do it and I have not run into that here." | There is now a system in place, something that not everyone else has, [a system of Bricklabs across the school.] |
Inquiry Based Learning

With all the basic skills that are being taught in elementary, adding inquiry to it is a "mind shift," requiring reflection, time and coaching.

It seems to help students really understand what they are doing (and transfer knowledge).

Not mentioned. What was mentioned a lot was an increased willingness to try new things (getting over the "fear factor").

It's founded in inquiry-based learning -- our demographic of students need that tremendously. Our students need exposure to the opportunity to share what is important to them and SySTEMic does that. "For example, they built the Green City with their project and their idea of what that entailed was so incredibly different from what was being presented to them and what was important to them." "In and of itself it has really created an opportunity for students to really take that risk-learning, to really step out of that question and answer box and be able to say here is what I CAN do."

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Q4: What are some ways you promote or support STEM teaching with your teachers here?

| I promote science (not STEM per se), through dialogue with teachers. And, We need to look at what the students' needs are and incorporating math science technology through everything we do is my goal as principal. | She promotes incorporating STEM into the new common core -- getting teachers to think through how incorporating STEM would play out in a project or in a classroom on a daily basis -- "where I want to get to is that whole inquiry based learning." | Encourages science to be integrated into the other subjects (rather than teaching science every Thursday from 2 to 3). Encourages science to be open-ended -- an opportunity for scientific inquiry as opposed to content acquisition. Promotes science through science night. Opens up opportunities for students to want to do science so that when teachers integrate science with the curriculum, students want to do the activity. |

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Mention of technology
We grapple, struggle with technology a limiting factor.

This principal very concerned with getting technology for the sake of spending money and getting technology without building need and foundational support behind it. "Instruction and curriculum should drive what the technology needs are; we shouldn't buy technology and then find a need for it." The entire school is equipped with document cameras and projectors already.

This principal is very strong on technology, project based inquiry learning. They have tablets in the school. (from Q1)

They have a technology night; mention of "fear in technology" having gone away because of communication, teaming, and supporting one another.

Mention of technology in terms of having classrooms with projectors and smartboards, which "has opened doors to things that they can demonstrate, presentations they can give, examples of clips they can show from different sources on-line…” (and mention of state money funneling through increasing technology).

Having document cameras and projectors in the classrooms (as opposed to being things that have to be dragged around) mentioned concerning ways to help teach science -- "not that that is the best way to teach science but it is one way to capture kids and ten be able to project here is what is happening from an instructional point of view."

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Q5: How would you classify or describe your faculty’s preparation to teach science/STEM?

| Variability of preparatio in terms of content; variability in terms of being able to integrate science with other subject areas. | Junior faculty are less prepared in terms of the science aspect; Senior faculty more prepared as science was their natural interest. | The faculty know their curriculum because a lot of them taught here I their grade levels a long time -- so they know what they are supposed to be teaching. "It is now tying it to the pedagogy, to the understanding of "How are we going to make them think about this so not only do we do an activity or experiment but WHY we're doing that activity or WHY we form a hypothesis and then making sure we ask that question of what are you going to be responsible for learning." | How science is taught varies significantly, depending on the teacher. "I know there are some that do what they need to and as soon as it is done, they move on. Others [who perhaps are more prepared to, or interested in science] find ways to incorporate science and reading together to get it intertwined." | "The (science) knowledge that they come into in the profession is minimal at best. I think it gives itself enough to the idea of "you need to integrate this into other areas." I see new teachers being able to do that much better than their predecessors." And, "I would say it's true of anything that teachers that really enjoy it [science] have more content knowledge behind it without a doubt. |

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we have a hired staff member whose job is to teach engineering. This is a former employee of a large engineering firm, an engineer. They are a resource to the teachers -- the in-house expert. We also have a middle school faculty who teaches engineering 6, 7, 8 and geography.

How science is taught varies significantly, depending on the teacher. "I know there are some that do what they need to and as soon as it is done, they move on. Others [who perhaps are more prepared to, or interested in science] find ways to incorporate science and reading together to get it intertwined."
<table>
<thead>
<tr>
<th>Variability of implementation; authentic teacher buy-in (this also shows up in area under what ideas do you have for next time).</th>
<th>No issues here; the whole school is bought into the concept -- he personally hired all the staff when the magnet school opened so there hasn't been any push-back in terms of buy-in.</th>
<th>&quot;The teachers that do use this program do it well.&quot; And: The teachers are rebounding from &quot;No Child Left Behind,&quot; which &quot;almost put us in a box of 'this is reading and this is my reading book.'&quot; Just beginning to grow a cross-curricular capacity.</th>
<th>&quot;Some of the teachers grab on and want to do it (Bricklabs) next year, and some be 'like I don't have time to do this.'&quot;</th>
<th>&quot;I think it has been a bigger change (referring to teaching practices) to those that have really embraced it for the process and not for the [free] credit. Realistically speaking, some only took it because they needed credits and there wasn't a charge for them to participate in the credits, but those who really went at it ...I have seen a huge turnaround.&quot;</th>
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<tr>
<td>Mention of confidence; teaming.</td>
<td>His faculty are strong in science, but lack confidence in it; Training is needed to bolster confidence of faculty in their ability to teach science.</td>
<td>Confidence mentioned in this way: &quot;(teachers) feel inferior when they are alone, but when they come together and trust one another they can do it.&quot; The word &quot;fear&quot; used later as they way he summarized how teachers respond to engineering tying into the curriculum. And then, &quot;I would say no matter what you do you start with a foundation for knowledge saying &quot;We want you not to fear this. This is something that you will enjoy and it will help you and educate you and make our society better, we want to have Engineering being a part of this.&quot;</td>
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<tr>
<td>Ways the principal is addressing preparation</td>
<td>This principal brought up collaboration again, [as a way to address how elementary teachers have constrained backgrounds in math and science) because with this time, they can discuss Bricklabs, or whatever instructional projects they're working on. And, we're close to the national average (in preparation); we are low, for example, in math understanding</td>
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**Q6 Has there been a benefit from the whole school approach for Bricklab?**

<table>
<thead>
<tr>
<th>Fun/camaraderie</th>
<th>Camaraderie among faculty</th>
<th>&quot;They are excited about it.&quot;</th>
<th>&quot;Last year when we did the whole school challenge it was so much fun. It was the green city.&quot;</th>
<th>&quot;We realized through the SySTEMic project [that kids] respond well to science. Kids really enjoy that.&quot;</th>
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<tbody>
<tr>
<td>Common experiences</td>
<td>Common experiences among faculty</td>
<td>Common experiences</td>
<td>Common vocabulary</td>
<td>Common language</td>
</tr>
<tr>
<td>common vocabulary (for students and teachers)</td>
<td>Continuity between grades</td>
<td>Continuity between grades, with skills and techniques.</td>
<td>&quot;It was introduced in fourth grade last year and now in fifth grade they already know the rules of they bricks, they already know how to prepare and store them, they know why we have them in our classrooms that they are not just for free play but there is a purpose.&quot;</td>
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<tr>
<td>Mention of parents</td>
<td>Consistency: Helps eliminate parent preferences (&quot;I want that teacher because they do engineering and the other one doesn't.&quot; Parents help as volunteers with &quot;B-Bots&quot;.</td>
<td>Concerning technology night: &quot;I don't think that will be going away. The students really drove that, they built it, they completed it, and they got mom and dad to attend. It was packed there was no room in the gym. The first thing they did was go over to the tables to look at the cities the kids had built.&quot;</td>
<td>&quot;I have had some parents come in and tell me about things that their kids have done with their Logos at home and … it is not just this toy they have at home, they can also do multiplication, they can say, &quot;look what we did in class.&quot; The parents say, &quot;Wow, it's not just a toy, it is an instructional tool.&quot;</td>
<td>Science night -- &quot;it's a product of not only the SySTEMic project but a product of the students being excited about science and knowing that right away. That is what we are trying to build on is kids telling their parents &quot;I want to go to school that night to see how exciting this is!&quot; and once we get parents and</td>
</tr>
<tr>
<td>General compliment/compliment of Anne</td>
<td>You should be very pleased with the outcomes of this project; Thank you. &quot;It was motivational, the teachers loved it.&quot; ...the implementation aspect was done well -- the way that teachers were forced to implement it.</td>
<td>&quot;I just have to say Anne is great. She came and met with me for over an hour and a half. I had a lot of questions in the beginning and I wish that if this wasn't my first year I would have taken that class with them too...I like this project being inquiry based, I like that.&quot;</td>
<td>&quot;It's been really fun and I am really glad that I said yes. A lot of times you don't want to add one more thing to do, but I am really glad I said yes. I think this has been a valuable tool to my teachers.&quot;</td>
<td>&quot;We will continue with the SySTEMic project just because it's great for kids and it brings them in, especially with kids that are resistant learners. In addition, Legos are expensive. My population cannot afford them. So with my population of kids this is their first time to mess with them and that is how it is. This is an opportunity for them, it is an opportunity for them to go home and say we did something cool in school today...That is what SySTEMic has allowed us to do.&quot;</td>
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| school culture shift; mention of collaboration among teachers | "It's a complete shift in how you plan" -- that cross-curricular thing is kind of a lifestyle and it's a complete change of thinking on how teachers plan. | This school had purchased some Bricklabs the year before the project started. So, there was interest and wide buy-in to the whole-school approach. | Teachers are more open to new ideas (as a result of being in this project). "I can tell you just from being in other buildings, it is easier for me to go to them with my ideas." "I can already see the flexibility and the openness for ideas that they have." | "It has opened doors for teachers for new ways of thinking and new ways of doing things." | "It's been a school culture shift in that they have learned that there is not just one way to do something." |

<p>| school culture shift; mention of collaboration among teachers (cont) | It has to become cultural. Inquiry is a big shift if you aren't doing it. | Having all staff trained has been important -- when just part of the staff was trained, the &quot;others were eyeballing them and saying, 'what are you doing and why are your kids liking the activities and buying in more than mine?'&quot; This principal mentioned how inquiry method had crossed over from using strictly Bricklabs in their teaching into other media (in a fourth grade class). | [Because in this school there is weekly collaboration time, teachers have time to have that discussion of what is it that we are doing in math, what are we trying to target in this area and how are we going to do it or what is it going to look like.&quot; | &quot;where you can sit down and collaborate with a grade level and say I want to use bricks for this concept and lets think of a way that can work. I think it has caused a shift in culture just because it is something familiar that they all have used.&quot; | &quot;We will continue with the SySTEMic project just because it's great for kids and it brings them in, especially with kids that are resistant learners. In addition, Legos are expensive. My population cannot afford them. So with my population of kids this is their first time to mess with them and that is how it is. This is an opportunity for them, it is an opportunity for them to go home and say we did something cool in school today...That is what SySTEMic has allowed us to do.&quot; |</p>
<table>
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<tr>
<th>Q7 How have the mentors influenced teacher practice and teacher development in developing STEM related instructional practices?</th>
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<tbody>
<tr>
<td><strong>active users/role models</strong></td>
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<tr>
<td><strong>helping communicate</strong></td>
</tr>
<tr>
<td><strong>helping meet deadlines; being available</strong></td>
</tr>
<tr>
<td><strong>helping with figuring out what did work and what didn’t work year to year.</strong></td>
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<tr>
<td><strong>critical to success of project</strong></td>
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**Q8 What ideas do you have for a next generation of whatever we do?**

| ideas related to current project | Have (even more) follow up, throughout the school year. | Continue to build capacity around STEM -- there is room for growth on both the teachers' side and on the students. Perhaps add arts to it (STEAM). | if project were to continue, get feedback from current users in terms of why some teachers chose not to use them (as extensively as others). Get feedback, get teachers together saying, "how is that working?" |

Pointed out that this project created opportunities for teacher leadership.
<p>| scheduling ideas | Workshop in summer, 3 or 4 days. | 2 to 3 hour increments presented throughout the year -- he feels these are better than the 1 and 2 day workshops that send teachers back with more work than when they left! Notes that summer training is not conducive to creating school-wide implementation (he likes the 2 to 3 hour and sub model). |
| authentic teacher participation; real &quot;buy-in&quot; | There is always going to be..”I don't want to have to take the time to learn something new.” “I don't have time to do this.” “It's another took that they are not sure how to tie it into or they don't want to spend the time.” | “I think it has been a bigger change (referring to teaching practices) to those that have really embraced it for the process and not for the [free] credit. Realistically speaking, some only took it because they needed credits and there wasn't a charge for them to participate in the credits, but those who really went at it ...I have seen a huge turnaround.” |
| The ideal activity could include access to an expert - - someone the teacher could &quot;ask a stupid question&quot; to. | A train the teacher model would be beneficial -- perhaps with one person in each wing -- proximity is huge with mentoring. Having one just &quot;in the building&quot; isn't enough. | |
| Principal noted that his teachers are balancing everything against skill groups and developing the systems to make those things work -- skills like, &quot;why isn't Joe getting the BR sound? And why can he not make his vowel sounds and everyone else in the class can and what can I do differently for him.&quot; | | |</p>
<table>
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<tr>
<th>Wants a way to pay teachers for Saturday morning or from 4 to 6 for prof. development, as he wants to keep the teachers in the classroom (and not buy their day out with a sub in order to do professional development) (from Q1)</th>
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<td>Suggested getting more into robotics.</td>
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<td>Many various suggestions, all involving technology.</td>
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<td>&quot;Hands on&quot; and add technology (meaning in this case, projectors and ELMOS? Send it out in blogs.</td>
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<tr>
<td>The mentor said: &quot;I think Engineering is one of those things that teachers really aren't sure if they are doing engineering or not.&quot; So -- explicitly adding some reflection aspects on &quot;how is this activity linked with engineering,&quot; would be helpful. (p.5)</td>
</tr>
<tr>
<td>&quot;What is the next step for us to continue to get the support and the knowledge, because we would love to continue to have that and would love to continue to do the things to help our students and our staff truly be prepared.&quot;</td>
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<td>&quot;wanted to know if there was going to be another whole-school challenge. Pointed out that there is an ongoing need for some more training for new staff members -- expressed a desire for project continuity.</td>
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<tr>
<td>more of the existing project</td>
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<td>parent training</td>
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<td>(concerning math, mainly): &quot;The kids are learning differently than the parents learned so they don't know how to help their kids at home, so it's like we need to do workshops and have the parents come and learn math the way their kids are learning it because it is a shift in the instruction, it's a shift in thinking.&quot;</td>
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<td>take social responsibility and tie it in with science</td>
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<td>teacher-leader model for professional development (as a result of the fact that the mentor aspect of the existing project really resounded).</td>
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<tr>
<td>create an academic system where kids receive what they need at the level in which they need it.</td>
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