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RESEARCH IN MATHEMATICS EDUCATION

STEM Academy for Science Teachers and Leaders: 2018 Teacher Academy 2 Evaluation

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STEM Academy for Science Teachers and Leaders: 2018 Teacher Academy 2 Evaluation

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Executive Summary

Nearly one million additional STEM graduates will be needed over the next decade in order to meet the United States' increasing demand (Smithsonian, 2018). The STEM Academy for Science Teachers and Leaders is an intervention designed to support middle school science teachers and leaders in the Dallas Independent School District (ISD), with a goal of encouraging students' interest in STEM fields and ultimately STEM career pathways.

This report focuses on the experiences and perceptions of the first cohort of teachers participating in the second of three STEM summer academy courses. The summer academy course is titled *STEM Academy for Science Teachers and Leaders 2: Engaging Students through Inquiry in STEM Education* (Academy 2 hereafter). The content of Academy 2 was structured around four main pillars that were identified during the development of the STEM Academy goals as especially influential in fostering both student and teacher interest and success. These pillars are (a) inquiry-based instruction, (b) scientific process standards, (c) deep content knowledge, and (d) differentiated support for all learners.

This report summarizes teachers' perceptions of their experience in Academy 2 during Summer 2018. These teachers were part of the first cohort of participating teachers who attended Academy 1 during the summer 2017 and received coaching during the 2017-18 academic year. The structure and content of Academy 2 built on teachers' experience during the first year of participation in the program, including the previous Summer Academy in 2017. Academy 2 addressed pedagogical strategies that would help teachers develop the skills identified by and associated with the four pillars mentioned above. In addition, feedback from the teachers over the course of the academic year, including coach perceptions, helped guide what content would be most valuable to include and would help achieve the STEM Academy goals.

In addition to summarizing the experiences and perceptions of Cohort 1 teachers (n=12) regarding Academy 2, a second purpose of this report is to describe the activities and experiences and their connection to one or more of the foundational pillars. The results from a teacher survey of Cohort 1 teachers are classified using the four pillars as categories, and the open-response feedback is sorted and reported accordingly.

The results indicated that 100% of Cohort 1 teachers who participated in Academy 2 found their experiences to be valuable. Specifically, 100% of the teachers agreed or strongly agreed that Academy 2 helped them improve their science instruction, was interactive, should be shared with colleagues, and met their expectations. On the open-ended response items, 100% of Cohort 1 teachers identified an aspect of Academy 2 that was useful to them. Of the 30 comments given by the teachers, 24 were positive (80%), even though one of the three questions specifically asked for areas of improvement. One teacher said "I truly enjoyed the learning experience," and another said "I love this academy and I've learned so much."

The teachers' perceptions identified that Academy 2 deepened their knowledge of the four foundational pillars as evidenced by 100% of Cohort 1 teachers agreeing or strongly agreeing with statements about the quality of instruction, demonstration, and materials provided

for inquiry-based pedagogical strategies, incorporation of the process standards, teacher content knowledge, and differentiation and on-going support.

Three recommendations are made based on teacher perceptions of Academy 2 as measured by the teacher survey. First, the core structure and activities within Academy 2, especially the emphasis on the 5E Instructional Model (5E), should continue with minor if any adjustments in future years. This recommendation is based on teachers' overwhelmingly positive perceptions of Academy 2. Additionally, on open ended items, six of the 12 teachers (50%) explicitly referenced the emphasis on the 5E model as one of the most helpful aspects of Academy 2. Second, teachers valued more structured community-based STEM education resources such as the DART headquarters visit and the mobile planetarium over less structured experiences like walk STEM, talk STEM. Thus, more structured community-based STEM education experiences should be continued or incorporated into Academy 2. Third, the time estimates for online modules should be reevaluated for accuracy. Two of 12 teachers (17%) expressed that they felt that the online modules required more time than suggested within the modules.

Table of Contents

STEM Academy for Science Teachers and Leaders: 2018 Teacher Academy 2 Evaluation

Background

According to the Smithsonian Science Education Center, the number of STEM-related jobs grew three times the rate of non-STEM jobs between 2000 and 2010. As the number of available jobs continues to rise, leaders of STEM-related industries emphasize the critical need for more students interested in STEM, especially students from underrepresented subgroups including Black and Hispanic students (Smithsonian, 2018). In 2013, Texas House Bill 5 (HB 5) required that Grade 8 students select an endorsement area, including STEM, Business and Industry, Public Services, Arts & Humanities, or Multidisciplinary Studies. During the 2014-2015 school year, just 16.9% of Dallas Independent School District (ISD) students selected the STEM pathway, despite the fact that a wide range of STEM industries are based in Dallas.

In response to these statistics, a partnership between the Texas Instruments Foundation, the O'Donnell Foundation, Southern Methodist University (SMU), and Dallas ISD was established. A primary goal of this partnership was to determine how students' interest and perseverance in STEM could be significantly improved, and how this ultimately affects the STEM pipeline and equity in the technical fields. Four key areas were identified, including (a) inquiry-based instruction, (b) scientific process standards, (c) teacher content knowledge, and (d) differentiated support for all learners, with an emphasis on social and emotional learning (Perry, Reeder, Brattain, Hatfield, & Ketterlin-Geller, 2017). Through these conversations, desired outcomes were determined that would help initiate and refine the goals of this 4-year project (Perry et al., 2017). The primary desired outcomes included (a) an increase in student science achievement and engagement, and (b) an increase in teacher implementation of active learning experiences.

Overview of Project

The STEM Academy for Science Teachers and Leaders project includes two primary components. First, intensive summer academies provide 90 hours of professional development focused on inquiry-based instruction, scientific process standards, teacher content knowledge, and differentiated support for all learners. Second, academic year support which includes two parts: (a) regular onsite coaching and observation with an SMU coach aimed at emphasizing sustainability and implementation of the content of the summer academies, and (b) collaboration within a professional learning community. Participating teachers engage in these two components of the program each year of participation for up to three years. For additional detail about the project, please reference previous evaluation reports (Adams, Hatfield, Cox, & Ketterlin-Geller, 2018; Adams, Hatfield, Cox, Mota, Sparks, & Ketterlin-Geller, 2018; Perry et al., 2017).

The program follows a cohort model. At the time of this report, the first cohort of teachers was in their second year of participation (Cohort 1), and a second cohort of teachers was in their first year of participation (Cohort 2). Cohort 1 teachers began participation in summer 2017; Cohort 2 teachers began participation in summer 2018.

During their second summer of participation, Cohort 1 teachers experienced the *STEM Academy for Science Teachers and Leaders 2: Engaging Students through Inquiry in STEM Education* (Academy 2 hereafter). Academy 2 content is structured around four main pillars that were identified during the development of the STEM Academy goals as being especially influential in fostering both student and teacher interest and success. These pillars are depicted in Figure 1.

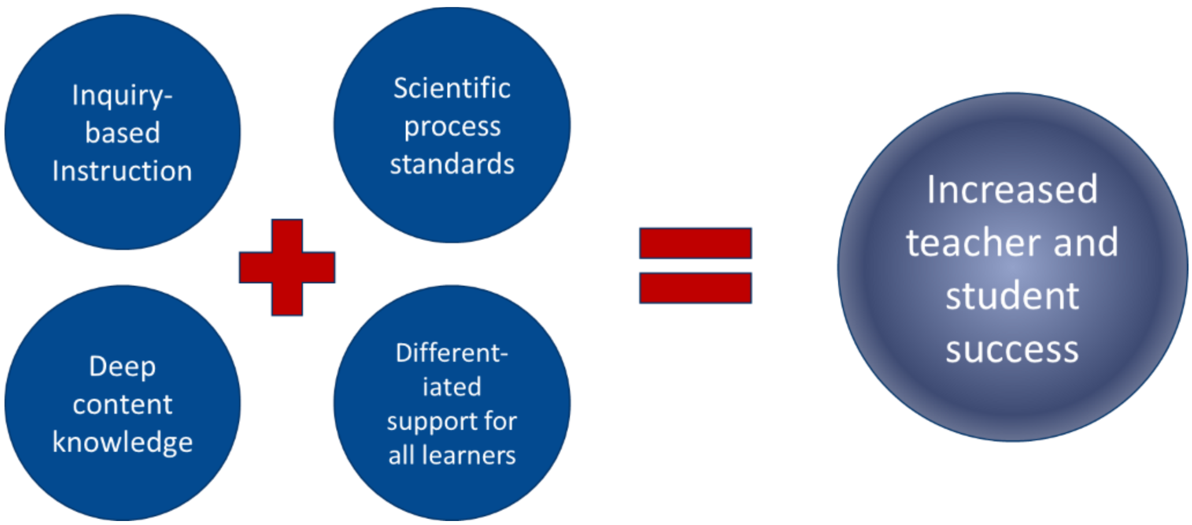

Figure 1. Foundational Pillars of the STEM Academy

As shown in Figure 1, the main outcome of the STEM Academy is student-centered (i.e., increased student success). However, the pathway to achieving these goals lies with the teachers. An analysis of 138 studies conducted between 1984 and 2002 showed that active thinking and inquiry-based instruction in the science classroom led to better conceptual understanding by students (Minner, Levy, & Century, 2010), and a 2017 study was able to identify sustained professional development in inquiry-based instructional strategies for teachers as having a positive trend on student growth in science mastery (Marshall, Smart, & Alston, 2017). In addition, inquiry-based instruction has also been shown to narrow the achievement gap within scientific fields (Marshall & Alston, 2014; Geier, Blumenfeld, Marx, Krajcik, Fishman, Soloway, & Clay-Chamber, 2008). The effective utilization of inquiry-based instruction necessitates an understanding of the scientific process standards and deep content knowledge (NRC, 2000). Within the STEM Academy, differentiated support for all learners emphasized attending to students' social and emotional learning (SEL). Teachers who have higher social and emotional competence have been shown to have better teacher-student relationships and better management of their classrooms through differentiated support structures, which leads to better student learning (Jennings & Greenburg, 2009).

Academy 2 content built on these foundational pillars, which were introduced in Academy 1 (see Perry et al., 2017 for more detail). Academy 2 continued to develop teachers' understanding and implementation of maker-based instruction (MBI) and project-based learning (PBL). In addition, teachers utilized a framework called the 5E Instructional Model (5E) for designing inquiry-based lessons which has five components: Engage, Explore, Explain, Extend, and Evaluate. An exemplary inquiry-based lesson typically includes each of these student-centered components. Teachers engaged in lesson studies during which they determined the levels of inquiry by examining the essential features of classroom inquiry (e.g., student opportunity to explain and justify with evidence). Continuing Cohort 1 middle school teachers (n=12) from 6 Dallas ISD schools participated in Academy 2 during summer 2018.

Purpose of this Report

The purpose of this report is to: (a) provide an overview of the components and the goals of Academy 2, and (b) summarize Cohort 1 teachers' perceptions of the Academy 2 coursework, which occurred during their second year of participation in the STEM Academy for Science Teachers and Leaders.

This report details an evaluation of the summer Academy 2 coursework for Cohort 1 teachers. While school leaders also participated in a summer STEM Academy, this report focuses only on teachers who participated in the STEM Academy 2 and their experiences. This report includes information about the content and structure of Academy 2, demographic details about the participating teachers, and details the results from an evaluation survey completed by the teachers at the end of Academy 2.

The results of this report are designed to inform future improvements to the design and structure of Academy 2.

Evaluation Question

In addition to describing the content, structure, and activities included in Academy 2, this report focuses on the following evaluation question: What are teachers' perceptions of the STEM Academy 2 based on the academy evaluation survey?

Content and Structure of Academy 2

The SMU project team designed the content and structure of the Academy 2 to meet the goals and objectives of the project and align with the needs and constraints of middle school science teachers. To meet the practical constraints of the science teachers, the SMU project team conducted a portion of Academy 2 online and a portion face-to-face. Participating teachers received 90 hours of professional development: 70 hours of face-to-face coursework on the SMU campus during two weeks in July 2018, and 20 hours of online coursework. The online coursework was divided into two parts, 10 hours before the face-to-face academy and 10 hours after the face-to-face academy. Academy 2 was structured similar to Academy 1, which the teachers all participated in during the previous summer.

In keeping with the goals of the project, Academy 2 focused on inquiry-based instruction, scientific process standards, teacher content knowledge, and differentiated support for all learners. Building on current research in STEM education, MBI and PBL were selected as the inquiry-based pedagogical approaches during Academy 1. During Academy 2, these two approaches were revisited and additional strategies were offered by the STEM Academy instructors along with suggested modifications based on what the teachers reported had occurred in their classrooms during the previous year. Additionally, teaching strategies for using 5E and SEL were incorporated into Academy 2 and new community-based resources were included. In the sections that follows, these instructional approaches are described in detail.

Maker-Based Instruction

MBI is often described as 'content agnostic' by its practitioners, however, due to its focus on skills and the use of tools, it lends itself extremely well as a way to teach process standards in the science classroom. In addition, it allows for creativity and effective differentiation since students develop personalized solutions to a problem and the outcomes are variable, not pre-determined.

Typically, MBI is organized as a series of Maker Sprint activities, each of which helps students develop a specific skill utilizing a iterative design approach. The unit concludes with a Maker Sprint Cycle Challenge, which integrates the skills developed in the sprint cycles and culminates in the production of a tangible product.

Finally, MBI draws on teacher content knowledge by morphing the role of the teacher into that of a facilitator, which requires the teacher to have expertise in tools and techniques that the students may want to utilize in their inquiry process. The core principles of MBI include hands-on learning, open-ended problem solving, and high levels of student participation in order to attain classroom learning objectives.

Project-Based Learning

PBL is an active learning strategy that emphasizes real world problems or scenarios, and then requires the students to lead their learning by investigating the issue, analyzing the presented problem, and ultimately developing a solution. PBL typically is conducted over an extended time period and the goal is to engage students in problems that matter. The solution to the problem may be multi-faceted, should be subjected to testing, and is typically presented to an audience for additional evaluation and judgement. The teacher's content knowledge is essential because projects will often be cross-curricular in nature and the teacher will be required to guide the students to resources and connections. Differentiation occurs at the problem development phase, and a single classroom may have multiple essential questions directing a variety of projects.

5E Instructional Model

In 5E, the Es stand for engage, explore, explain, extend, and evaluate. The 5E Model is intended to help students build an understanding of content that will be more authentic than what can be achieved by direct-teaching methods. Typically, the teacher will direct the investigation into a specific set of process or content standards, and differentiation will occur at the levels of explore or explain.

Social and Emotional Learning

SEL was first formally introduced during Academy 1, and although direct training on the five social and emotional competency areas did not take place, SEL components were incorporated throughout Academy 2. (1)Self-awareness and (2)self-management factored in heavily during the beginning of the face-to-face academy as teachers identified what triumphs and challenges they had experienced over the past year. (3)Social awareness and (4)relationship skills were essential to completing Academy 2 due to the collaborative nature of many of the professional development activities, and (5)responsible decision making was considered when developing and designing classroom instructional activities. SEL strategies were typically incorporated into every part of the academy regardless of the pedagogical structure being utilized.

Community-Based Resources

Another component of the face-to-face portion of the STEM Academy involved teachers learning about community-based STEM educational resources by participating in field experiences including walkSTEM, talkSTEM, the Frontiers of Flight Museum’s mobile planetarium, and an in-depth tour of the Dallas Area Rapid Transit (DART) headquarters. Additional information on the topics from the STEM Academy and the community-based educational resources is included below.

Participants received concentrated professional development on these instructional approaches, which is explained in additional detail in the next section. Teachers also generated instructional units that employ these approaches to teach high-priority TEKS. Specific TEKS were identified as high-priority based on historically low student performance during STAAR exams and Dallas ISD common assessments, as evidenced by data provided by the district and also gathered from teachers for their specific campuses. Teachers in Dallas ISD often refer to these standards as “hard to teach, hard to learn.” Focusing on these TEKS during Academy 2 allows teachers to build confidence in these content areas and to work collaboratively with their peers and the SMU team to develop strategies to deliver this information to students efficiently and successfully. The resulting instructional units will be delivered during the 2018-19 academic year.

Activities within Academy 2

This section outlines the activities conducted for each of the primary content areas. The Academy 2 activities were designed to strengthen teachers’ understanding of STEM education as defined by the four foundational pillars. Academy 2 included online modules and face-to-face sessions. Teachers completed the online modules both before and after the face-to-face sessions. The following section describes each of these activities and the tasks included within each activity in detail. Information on the STEM Academy instructors can be found in Appendix A.

Pre-Academy Online Modules

Before the face-to-face portion of Academy 2, the participating teachers completed 10 hours of online coursework. These modules focused on three strategies including Question Formulation Technique (QFT), Three Act Tasks, and Informal Learning, with the goal of having teachers explore the development of essential questions and the impact of questioning strategies on active learning in their classroom. The following section describes the main emphases of the online modules that teachers completed prior to attending the face-to-face Academy 2 sessions.

Question Formulation Technique

During the online coursework, participating teachers read information about developing student curiosity and why questioning is essential to students engaging in the process standards. Additionally, specific TEKS were addressed that need to incorporate an aspect of inquiry, and teachers were asked to reflect on their own lessons from the previous year. Next, the teachers read an article from *Educational Leadership* that provided step by step guidance and suggestions for making classroom questions essential. Throughout the entire module, the teachers were asked to consider the information in regards to their own PBL lesson that they had developed in Academy 1.

The next online module built on the concept of essential questions by adding a student-centered factor. Several articles and videos asked the participating teachers to consider how giving up some of the control in their classrooms, thereby letting the students drive the direction of learning, would affect student engagement and classroom culture. The resources also offered solutions to common problems and recommendations for how to guide student inquiry in a direction conducive to mastery of the TEKS. The main SLOs (student learning outcomes) for this unit were to have the teachers:

- Design questions that spark student interest and promote inquiry
- Reflect on and discuss the role of curiosity and questioning as they relate to inquiry-based learning
- Incorporate instructional practices that help students generate questions to guide a learning experience

The final content delivered in this online module included specific details about QFT. Several specific steps were outlined, which included the abovementioned strategies of essential questioning and incorporating student interests. Specifically, QFT asks the teacher to present a question focus, but to then allow the students to formulate an abundance of related essential questions. The teacher then guides the students through a process of narrowing down the question options, selecting a question to focus on, and eventually refining the question and developing next steps in the inquiry process. This technique is the introductory step to an inquiry-based lesson, and allows for differentiation because students develop their own research topics by narrowing down a broad question to one that is testable. This is the process, specified in the process standards, by which scientific research is conducted. The module concluded with example QFT lessons and an assignment to help the teachers reflect on how well they understood the purpose and implementation requirements of QFT.

Three-Act Tasks

The next instructional strategy explored during the online portion of Academy 2 was the Three-Act Task. This method of inquiry-based instruction can be done within a single lesson, and can be used as a scaffold to develop larger PBL or MBI units. The first act is setting up the problem of interest. An example given by the developer, a math teacher, was a video of a man shooting a basketball at a basketball hoop. The teacher then paused the video when the basketball was at the top of its arc, and this naturally generated discussion amongst the students about whether the ball was going to go through the hoop. During the first act, the students engage in process standards by formulating hypotheses, developing methods to test their hypotheses, and identifying equipment and additional information required to complete the task.

The second act is to solve the problem, typically by applying the content or formulas that the students are currently learning. This may involve new material being introduced by the teacher or it may include the students doing independent research in order to determine what the outcome of the scenario might be. This step is a good opportunity for a teacher to differentiate instruction, because each group may be supplied with differing amounts of support or information based on their ability levels.

The final act is the reveal, which typically confirms (or not) the students' results. This strategy fosters student involvement and engagement by requiring them to be part of the process. It also allows the teacher to assess the students' understanding by observing what steps they took to solve the presented problem. This strategy also offers excellent opportunities for the teacher to offer feedback based on formative assessments to each student or group. This technique was first developed by a mathematics teacher, so there was discussion about how to adapt this pedagogical strategy to science content and its connection to the scientific process standards. The teachers utilized their own content knowledge to identify what areas are appropriate for implementation of the three-act tasks.

Informal Learning

The final module covered in the online academy prior to the face-to-face content was focused on informal learning. The teachers read several articles and studies emphasizing the importance of informal learning in the science classroom. Specific focus was put on current scientists, how and when they developed their interest in the field, and innovative approaches to content delivery. The student learning outcomes (SLOs) were for the teachers to:

- Describe the value of how informal learning experiences can further support students relating to the authentic culture of scientists and STEM
- Understand the value of engaging girls and minorities in STEM to support the pipeline of STEM careers
- Plan informal ways of integrating STEM awareness and careers into the school year

The teachers watched videos and read articles pertaining to online courses, the use of technology in the classroom and at home, distance education and the shrinking world, and the use of gaming as an instructional tool. Next, the teachers considered their own content knowledge and experience with the process standards to imagine how something traditional like a science laboratory activity could be delivered in an unconventional manner. To conclude this module the teachers reflected on how they could incorporate more informal leaning opportunities into their classroom and participated in a discussion board where barriers to informal learning were acknowledged and potential solutions were developed.

Face-to-Face Academy Sessions

Participating teachers engaged in 70 hours of face-to-face Academy sessions on or near the SMU campus. The section that follows describes the five main emphases of the face-to-face Academy 2 content and activities, which included MBI, the 5E Model, PBL, SEL, and community-based STEM education resources. The following section describes the main emphases of the face-to-face Academy sessions.

Maker-Based Instruction

To begin the face-to-face portion of the academy, Dr. Rob Rouse and Katie Krummeck reviewed MBI for returning Academy 2 teachers. The instructors specifically described the SMU Maker Truck, maker spaces, and what MBI looks like in the classroom. They then introduced several Maker Sprints as a part of a Graphic Design and Vinyl Cutting Sprint Cycle. Maker Sprint Cycles are a process in which students iteratively learn to use a tool, while engaging in a series of content focused activities. Teachers engaged in a discussion about icons that would form the basis of the teachers' subsequent activities. The main SLOs for this unit were for the teachers to:

- Compare and contrast the purpose of the three modes of maker-based instruction: exploration, skill building, and challenge
- Actively engage in an MBI sprint cycle and explain the value of using MBI to support STEM integration in the classroom
- Reflect on practical implementation of MBI in a middle school content-focused classroom
- Refine the MBI resources and plan for implementation

During the afternoon session on the first day, the first Maker Sprint was an exploration of the concept of an icon and a discussion of how logos and icons differ from each other. Utilizing an activity that crosses over into the visual arts and technology curriculum areas, while still having science content as a focus, allows for this activity to reach a wider range of students with differentiated interests and abilities and still have the desired content connection. The teachers created a mood board with graphics that reflected their self-image, and then participated in a gallery walk in order to critique their peers' mood boards using the 'I like, I wish, I wonder' strategy of giving feedback. The logo that the teachers ultimately designed represented themselves, so both the design and critique sessions were an opportunity to utilize SEL strategies that had been previously covered in the academy. To conclude this portion of the session, the teachers then modified their mood boards in response to the feedback they had received. The session concluded with the teachers drawing a graphic that synthesized their moods.

The next Maker Sprint was led by Alain Mota and Dimitri Higginbotham. The teachers worked to develop a logo design representative of themselves and offered feedback to the other teachers. The simplicity of a logo design required the teachers to distill their original ideas down to the most relevant aspects of their personality and teaching style. The third Maker Sprint transformed the hand drawn logo into a vector drawing. To create the logo, a free online program called Vectr was utilized. Vectr does not require coding but allows the user to either select from a variety of pre-made shapes and symbols or draw their own images. Typical characters are available, as is a large database of previously created images.

As the logos neared completion, another peer critique session was conducted, followed by an opportunity for revision. An important aspect of MBI that was modeled is the opportunity for revision as an iterative process. During the fourth Maker Sprint, the logo designs were also checked for practicality of translation to vinyl and a T-shirt, which required considering how the vinyl cutting machine works. Some designs needed modification due to size, proportion, symmetry, orientation, and/or concerns about the intricacy of some portions. Once the logo designs were completed, the teachers engaged in a vinyl cutting basic training. They learned about the software and the vocabulary used in the industry, then for the final Maker Sprint Cycle Challenge, actually created their cut-out logo and transferred it to their T-shirt using a heat press.

After each Maker Sprint within the Graphic Design and Vinyl Cutting Sprint Cycle, participants were asked to reflect on how the ‘content agnostic’ design could be utilized in their science instruction. The questions included:

- What ‘aha’ moment do you have from this sprint and why?
- What are some challenges and how would you mitigate those challenges in your classroom?
- What is a set of content and process TEKS that could be used for this Maker Sprint?
- What is one career pathway that could result from the increased skills and tools used in this Maker Sprint?

Following the above experience and reflection, participants worked in groups to design a unit around three of the five maker sprints they had experienced. Participants utilized a template provided to support the unit creation. Feedback was provided on the unit design and teachers were encouraged to utilize the plans during the 2018-19 academic year.

The 5E Instructional Model

The next major instructional strategy discussed during Academy 2 was the 5E model. This strategy is utilized in Dallas ISD, and the teachers were therefore relatively familiar with it. Alain Mota led five exploration activities followed by a design cycle focused on addressing a high stake TEKS. The main SLOs were for the teachers to:

- Discover and analyze the essential components that describe inquiry-based instruction and its relevance to the STEM integrated classroom
- Research the development of the 5E model and interpret the relevance to their teaching practices
- Summarize teacher and student behaviors during the delivery of lessons
- Use the design cycle to create a 5E lesson addressing the needs of all learners

The first exploration began with the facilitator asking the teachers to share what they already knew about 5E and how they were already utilizing it in their classrooms. The levels of 5E are: engage, explore, explain, extend, and evaluate.

During the second exploration activity the teachers evaluated and compared lessons from two different science teachers, and specifically determined where partial inquiry versus full inquiry occurred. Based on their observations, the teachers then generated ideas to increase student engagement and conceptual understanding in the partial inquiry lesson.

In the third exploration activity, the teachers reflected on their own classroom behaviors and evaluated their own practices for process standard inclusion and full inquiry design. The exemplar of the full inquiry lesson from the second exploration was referenced and teachers were asked to consider why specific variations of essential lesson features were chosen.

The fourth exploration activity on the following morning asked the teachers to evaluate lesson segments developed by a different teacher and arrange them in an appropriate manner to promote understanding. The teachers discussed their organizational choices and used the process standards as evidence to support their statements.

For the fifth exploration activity, the teachers read through a vignette and applied what they knew about the 5E model to the lesson. They identified which portions of the lesson fit into each of the 5E sections and discussed their determinations with their peers and the facilitator. To complete the 5E sessions, the teachers divided into school groups and participated in a design cycle during which they developed their own lessons incorporating 5E and inquiry-based instruction. 5E was also embedded into the PBL activities which are described in the next paragraphs.

Project-Based Learning

The first two PBL sessions began with an SMU facilitator modeling a PBL unit for the teachers. Dr. John Easton lectured about water usage, water availability, and water quality, both historically and in the present day. Teachers reflected on the PBL attributes by identifying how the project addressed a specific problem and was focused on an end product designed to solve a real-world problem. The teachers considered all of the different ways that water is used on a daily basis, and also what type of emergency reserve may be required for things like firefighting, or large industrial or commercial usage. Then, teachers were introduced to a fictitious town and were asked to design a water system for its particular needs. They then built a model of their proposed system using maker space materials. The essential question guiding this activity was: How do you design a system to meet water usage needs 24/7/365? The facilitator also reminded the teachers to think about topography, geography, school locations, houses, factories, office buildings, and street patterns. They then considered whether to use a grid or a branching pattern and discussed the benefits and disadvantages of each system. Once the models had been built, the teachers conducted a gallery walk to discuss the proposals that each group had generated, and to discuss additional concerns or solutions. To wrap up this session, big issues of future environmental engineering were considered,d such as wind and solar energy, water purification and usage, and climate change.

Through the model PBL unit, teachers were exposed to career connections that directly related to science TEKS in middle school. In addition during the PBL portion of the academy, the teachers engaged in the following SLOs:

- Experience components of standards-aligned PBL by using scientific inquiry methods to investigate a TEKS-based sample PBL experience
- Apply understanding of the PBL design elements to evaluate and revise student learning experiences
- Participate in and evaluate the use of a variety of inquiry-based instructional routines
- Use facilitation strategies to promote critical thinking, scientific reasoning, and problem solving
- Develop formative assessments to assess students' inquiry process throughout a project
- Demonstrate PBL teaching practices in a simulated classroom

For the second portion of the PBL part of the academy, Robyn Hartzell expanded on the PBL work the teachers had done in Academy 1 through reflection and honing of teacher skills to facilitate a rigorous and productive PBL learning environment. First, the facilitator led a discussion amongst the teachers about their own experiences with PBL over the previous school year. Teachers rated how well or poorly the unit had gone and discussed possible explanations for the successes or failures. Based on the reflections, the facilitator focused on techniques teachers could use to put checks and balances in place for student success in an active learning classroom. Then teachers divided into small groups and connected the steps of a PBL project with the categories of the 5E model and 3-act tasks so they could see that different instructional models share many of the same components with the underlying theme of active learning. The teachers selected one of the projects that they had developed during the previous summer and worked to refine it by revising the essential questions and designing a more detailed instructional guide that they could use to implement the lesson. The instructional guide included specifics about procedures for techniques that could support student thinking through the question formulation technique that was taught in the pre-online academy content.

The next day as teachers continued to work on the instructional guides, the facilitator did check-in activities so that she could gauge their comfort level with the process and continue developing teacher skills in student engagement strategies.

The culmination activity of the PBL instruction for Academy 2 was a visit to the Mursion Lab. This is a virtual reality classroom simulation where teachers teach in front of interactive virtual students and can then review and assess the video of their lesson. Mursion was developed by drawing upon principles of psychology and learning science, such as the need to try new pedagogical techniques while controlling the classroom environment through the use of technology, without losing the benefit of actual human interaction. The virtual classroom is projected on a monitor for the practicing teacher and contains up to six students, whose behaviors and voices are controlled by a technician provided with scripts and information about what the teacher will do and how students should respond. This means that the students interact with the teacher in real time. The purpose of this experience was to provide teachers with an opportunity to try out the student engagement strategies for launching a lesson, including the question formulation technique. To prepare for this, the teachers practiced delivering their lesson by role playing both the teacher and student parts with their peers. Then, the teachers launched a lesson to the virtual reality students in the Mursion Lab. Finally, teachers had a debriefing discussion with their colleagues and the instructor and were sent the digital recording of their lesson for further examination.

Social and Emotional Learning

SEL instruction was integrated into several of the activities. For example, during the gallery walk, the teachers were reminded about strategies to give feedback in a way that constructively builds the recipient's awareness of the product and helps develop solutions to potential problems. This directly correlates to the self-awareness and social awareness competency areas of SEL.

On a different morning, the session started with teachers selecting an emotion card that exemplified what they were feeling that day. They were asked to verbalize their emotion and explain why that particular emotion was the most prevalent for them at that time. This led to a group discussion about some commonalities in the emotions that the teachers were experiencing regarding the implementation of inquiry-based instructional strategies in their classroom. The teachers then viewed slides that expressed different opinions about inquiry in the classroom, and they discussed which ones they agreed with, which they disagreed with, and why. These activities drew upon both self-management and relationship skills within SEL. Other SEL strategies were incorporated into the multiple exit tickets, 'let's talk' discussion sessions, and introductory periods where the teachers' comfort level with each new strategy was assessed by the facilitator.

Community-Based STEM Educational Resources

Teachers in the STEM Academy learned about three community-based STEM educational resources by participating in three field experiences. During the first week of the face-to-face portion of Academy 2, they participated in walk STEM, talk STEM and the Frontiers of Flight Museum's Mobile Planetarium on the SMU campus. The second week of Academy 2, teachers went to the Dallas Area Rapid Transit (DART) headquarters. The purpose of these field experiences was to deepen teachers' understanding of the power of informal learning, career connections, while also exposing them to possible in-school and out-of-school field trips for their own students. The specific learning goals were for teachers to:

- Understand how informal learning contexts facilitate student learning of relevant TEKS
- Explain how interest, motivation, and a sense of identity can be enhanced by exposing students to community-based STEM contexts
- Understand and apply a framework considering the value of an informal learning context for supporting SEL goals

Walk STEM, Talk STEM

Karen Pierce and Erica Simon facilitated the walk STEM, talk STEM activity on the SMU campus. This program is designed to facilitate awareness of surroundings and a no cost field trip at any location. The goal is to help teachers and students recognize that STEM content is present all around them. The specific locations visited during this excursion were Centennial Fountain, where water flow was assessed; Dallas Hall, where the dome's architecture, mathematics, and other historic features were analyzed; and Bishop Avenue, where a discussion ensued about the design and location of shade growing, large trees and the biology of their water uptake and evaporation systems. The teachers then reflected on how they could incorporate portions of the presented walk STEM, talk STEM activities into a field trip on their own campuses. Some of the teachers considered activities that could take place on their school campus, while others included locations that could be easily reached in the surrounding community. A discussion followed that analyzed grade level appropriateness of each activity, and how the content could be either elevated or simplified to make it appropriate for middle school students.

Frontiers of Flight Museum Mobile Planetarium

The second community resource that was presented during Academy 2 was the mobile planetarium from the Frontiers of Flight Museum. This was a giant inflatable dome that can be set up in a gym or large auditorium, allowing participants to enter the dome. There was a computer and laser light machine located in the center that projected different images onto the inner surface of the dome. Similar to what is observed in a full-scale permanent planetarium, the mobile planetarium showed locations on Earth, surfaces of other planets in our solar system, various moons, the pathways between different celestial bodies, other solar systems and galaxies, constellations, and a 'zoomed out' view of the Milky Way galaxy. The planetarium facilitator provided information and answered questions that arose. One aspect that many teachers felt was the most helpful for their content was the ability of the planetarium to show why the moon changes phases. By looking at the moon and Earth from a distance, participants saw first-hand how their relative positions to the Sun caused the phase changes, which is an effective teaching tool for this historically tricky concept.

Dallas Area Rapid Transit Headquarters

The final day of the face-to-face academy was spent visiting DART headquarters. The teachers met at Mockingbird Station and were told about the strategic planning that determined station locations. The teachers then boarded a train and rode to Akard St. in downtown Dallas (the DART headquarters).

Once at headquarters, the teachers participated in a discussion with a group of DART officials. Each shared their academic background, their roles at DART, their expectations for the next generation of DART employees, and how soft skills play a role in scientific disciplines. The officials also described how STEM was integrated through cross departmental collaboration.

Teachers then rode one of the electric buses to meet other engineers who shared the prerequisite courses and qualifications for employment with DART. The teachers walked under a train and saw how repairs were done, and then toured the control tower to see how trains were tracked while in transit.

Other activities included riding in a bus while it was being washed and observing how the buses were refueled with compressed natural gas (CNG). The tour ended with the teachers getting off at Convention Center to see two of the electric charging stations for the electric busses.

Post-Academy Online Modules

After the conclusion of the face-to-face portion of Academy 2, the participating teachers completed a final 10 hours of online coursework. Three main strategies were emphasized during the online modules following the face-to-face Academy 2 including Accountable Talk, Reciprocal Teaching, and the Big Brain Protocol. The focus of these strategies was for teachers to explore how the classroom environment can impact collaboration and to learn about some specific strategies for promoting student conversations. The following section describes the main emphases of the online modules that teachers completed after attending the face-to-face Academy 2 sessions.

Accountable Talk

Accountable Talk is a strategy that allows students to make arguments based on evidence, and trains students to respect the views of their peers while strengthening their own communication skills. During the training, teachers were given example sentence stems on flash cards that could be utilized in the classroom.

Reciprocal Teaching

Reciprocal Teaching is a technique that assists students in understanding text passages on a deeper level. Typically, a student guides a group discussion using four specific strategies: summarizing, question generating, clarifying, and predicting. Each student is given a specific role, and the participating teachers learned how to implement this technique and also expand it to lessons that do not specifically involve a text.

Big Brain Protocol

The Big Brain Protocol is strategy that assigns specific roles to students and is intended to help with collaborative problem solving. The teachers watched a video of a classroom using the Big Brain Protocol, and then completed an assignment in which they planned how to use all three strategies covered in their own classroom during the first 6-week grading period.

In summary, the content of both the online and face-to-face portions of Academy 2 supported the Cohort 1 teachers in furthering their understanding of the four of the foundational pillars. Pedagogical strategies that incorporated the scientific process standards and science content knowledge were presented, and the teachers had opportunities to develop lessons that they could directly implement into their classrooms as the primary lesson architects. SEL was incorporated throughout Academy 2, which offered multiple strategies for differentiating instruction for a wide variety of learners. Many of these strategies specifically utilized inquiry-based instruction as a mechanism for increasing student engagement, interest, and ultimately success.

Participating Teachers

Overall, 12 Cohort 1 teachers participated in Academy 2 in summer 2018. Of those participating teachers, 12 completed the academy evaluation survey, resulting in a response rate to the teacher survey of 100%. Table 1 shows the demographic characteristics of the Cohort 1 teachers who participated in Academy 2 in summer 2018.

Table 1. Teacher Demographic Information

Teacher Characteristic		Cohort 1 Summer 2018	
		#	%
Gender	Male	3	25%
	Female	9	75%
Race	Alaska Native	0	0%
	Asian	0	0%
	Black	7	58%
	Native Hawaiian	0	0%
	Other Pacific Islander	0	0%
	White	5	42%
Ethnicity	Hispanic or Latino	3	25%
	Not Hispanic of Latino	9	75%
Total		*12*	*100%*

Table 2 shows teachers' average years of experience in education, teaching, teaching science, in other careers, and at their current school. On average, participating teachers had six years of teacher experience and nine years of experience in careers other than education.

Table 2. Teacher Work Experience

Years	Mean and Standard Deviation
In Education	5.7 (3.3)
Teaching	5.6 (3.4)
Teaching science	5.2 (3.0)
In other careers	8.9(6.1)
At current school	4.8 (3.4)

Note: Table includes 12 Cohort 1 Teachers

Table 3 shows the number of teacher certifications for Cohort 1 teachers. The majority of Cohort 1 teachers were certified in 1 subject-area, given that four of those 12 teachers obtained a second certification. Figure 2 shows the number of teachers who earned each type of certifications. Overall, eight of 12 teachers (67%) had earned a science-specific certification.

Table 3. Number of Teacher Certifications

Teacher Certifications	Count and Percent of Teachers	
	#	%
1 subject-area certification only	8	67%
2 subject-area certifications only	4	33%
3 subject-area certification only	0	0%
4 subject-area certifications only	0	0%
5 subject-area certification only	0	0%
6 or more subject-area certifications	0	0%

Note: Table includes 12 Cohort 1 teachers.

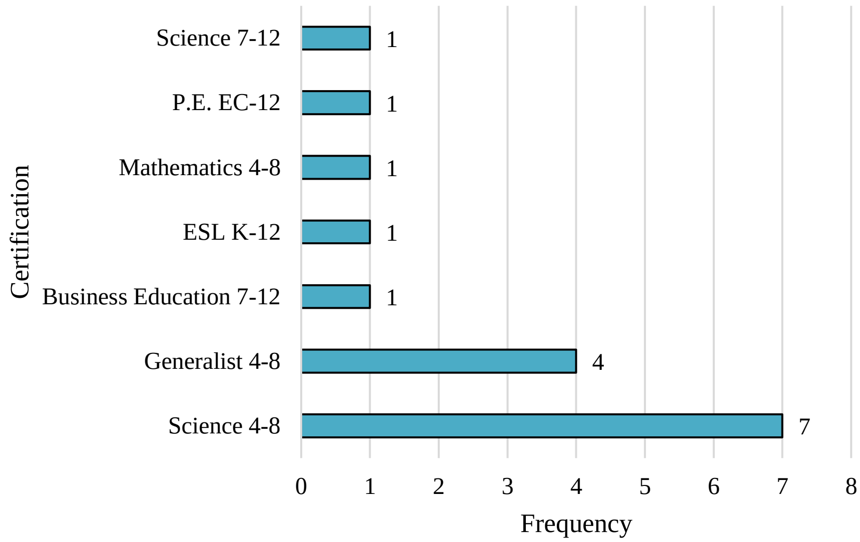

Figure 2. Cohort 1 Teacher Certifications
Note: Figure includes 12 teachers. Four teachers have two certifications.

Table 4 depicts the grade levels that teachers anticipated teaching during the 2018-19 school year. The majority of teachers (75%) anticipated that they would be teaching Grade 8 classes during 2018-19.

Table 4. Teachers' Grade Levels Taught

Grade Level	# of Teachers
Grade 6	0
Grade 7	6
Grade 8	9

Note: Table includes 12 Cohort 1 teachers. Three teachers in Cohort 1 taught more than one grade level.

Table 5 and Figure 3 show the number of hours of professional development by topic that Cohort 1 teachers engaged in during the 2017-18 school year. Overall, 12 teachers in Cohort 1 received professional development in science content (100%), which is most likely attributable to their STEM Academy attendance during the previous year. The second highest attended professional development topics were PBL, MBI, SEL, and English Language learners (92%), followed by students with disabilities (83%). Because PBL, MBI, and SEL were also main focuses of the Academy 1 content, teachers' professional development attendance for these topics was also most likely attributable to the STEM Academy.

Table 5. Cohort 1 Teacher Previous Professional Development by Topic

	Topic	Less than 6 hours	6-15 Hours	16-35 Hours	More than 35 Hours	# of teachers completed PD in each area	% of teachers completed PD in each area
Science	Science Content	0	1	3	8	12/12	100%
	Other Content	3	5	1	0	9/12	75%
	Project Based Learning	0	3	4	4	11/12	92%
	Maker Based Instruction	0	3	4	4	11/12	92%
Non-science	English Language Learners	3	3	5	0	11/12	92%
	Social Emotional Learning	2	5	2	2	11/12	92%
	Students with Disabilities	4	5	1	0	10/12	83%

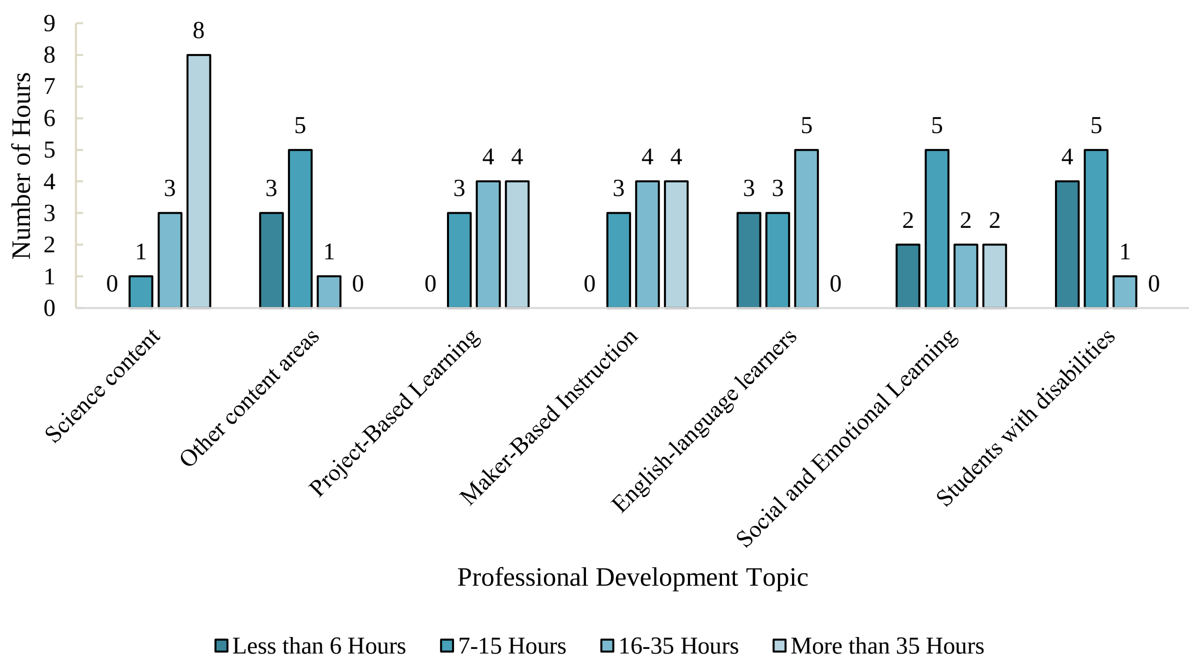

Figure 3. Cohort 1 Professional Development by Topic

Overall, the descriptive statistics for Cohort 1 teachers show that participating teachers were majority Black (58%) and female (75%). On average, teachers had more than five years of experience in teaching (5.6 years). On average, teachers in Cohort 1 were most likely to have one subject area certification. The most common subject-area certification was science; only four teachers were not specifically certified to teach science.

Academy 2 Evaluation Survey

Following Academy 2, teachers completed the *STEM Academy for Teachers and Leaders: Academy 2 Evaluation Survey*, which included 15 questions, six of which had multiple components, and allowed teachers to report their level of agreement with statements about the quality of Academy 2. Items focused on understanding teachers' overall impressions of the Academy 2 structure, content, and speakers. The survey was administered via Qualtrics (Qualtrics, 2018) immediately following the implementation of Academy 2.

The results in the following section summarize the academy evaluation data collected following Academy 2 with Cohort 1 teachers who continued in the program (n=12). Of the participating teachers, all 12 Cohort 1 teachers completed the survey, resulting in a response rate of 100%. Academy 2 was implemented for the first time in the summer 2018; thus change across years is not examined.

Results

The results in this section are guided by the foundational pillars and are grouped based on teacher perceptions (a) overall, (b) specific to *inquiry* in the classroom, (c) specific to application of activities that teach and incorporate the *scientific process standards*, (d) specific to *content knowledge*, and (e) specific to *differentiation* and on-going support for teachers. We examine teachers' perceptions quantitatively by looking at agreement rates. It is important to note that the sample size for Cohort 1 during the second year (2018-2019) is 12 teachers.

In addition, the survey included three open-ended items, which inquired: (a) about the areas of the academy that were most useful, (b) about the areas of the academy that need improvement, and (c) if teachers had anything else they would like to share. We examined Cohort 1 teachers' responses to these open-ended items qualitatively using a priori codes focused on the groupings specified above (i.e., overall, inquiry, the process standards, content knowledge, and differentiation and support).

Overall

Figure 4 shows the percent of Cohort 1 teachers who agreed or strongly agreed with statements about Academy 2 overall. These statements inquired about the extent to which teachers agreed that the academy was valuable, would improve their science instruction, met their expectations, enhanced their content understanding, gave them knowledge that they would share with their colleagues, and was interactive. Teachers responded with high agreement to all six of these statements, as evidenced by the fact that one hundred percent of the teachers (12/12 teachers) either agreed or strongly agreed with five of the six statements about the overall academy. In fact, 100% of teachers strongly agreed with four of the six statements, while the statement regarding the content meeting expectations, had 92% (11/12 teachers) strongly agree and the remaining 8% (1/12 teachers) agree. On one question, 'The structure of the STEM Academy enhanced my understanding of the science content I teach', 92% of the teachers (11/12) strongly agreed with this statement while the remaining 8% of the teachers (1/12) disagreed with this statement.

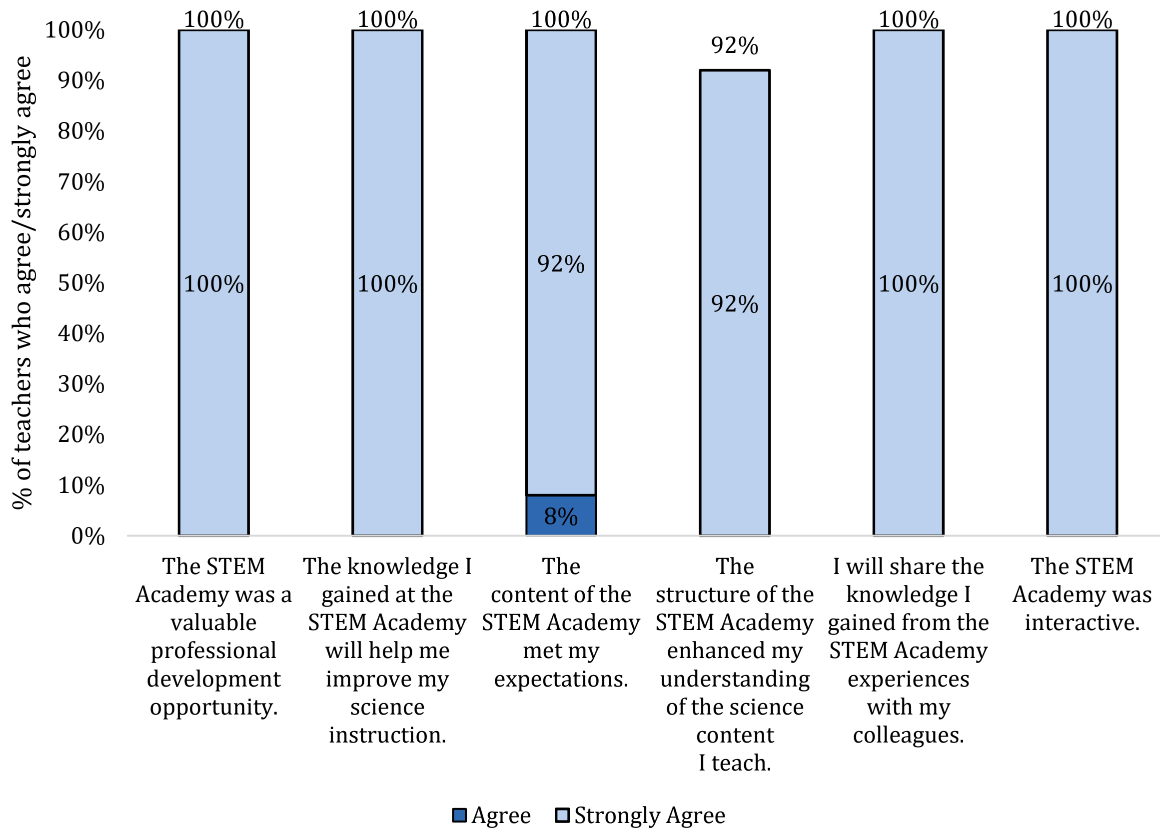

Figure 4. Percent of Teachers who Agreed or Strongly Agreed with Overall Statements about Academy 2
Note: Sample includes 12 Cohort 1 teachers.

In addition to the questions above, 100% of teachers made positive comments about the academy either overall or specifically related to one of the four core pillars in the open-ended response sections. Three teachers mentioned increased enjoyment of Academy 2 compared to Academy 1, one of whom specified that she was “impressed with the set up this year.” A different teacher mentioned that she “appreciate[d] the professionalism and helpful friendly attitude of the entire team.” In general, the comments showed that teachers felt that they learned new material and enjoyed working interactively with groups. One said she felt that the “interactive group assignments [and] sharing of ideas with other teachers and SMU staff” were the most useful parts of Academy 2, and only a few of the teachers identified aspects in need of improvement.

Three of the teachers (25%) identified an aspect of the academy that could be improved. One said that “sitting in class all day can be exhausting,” but then offered a solution stating that she “like[d] how on the last day we had rotations like mini classes.” The other two teachers with suggestions for improvement were concerned about the length of the online portions of the academy, and specifically mentioned that they felt that “some of the modules took a lot longer than the time indicated.”

Inquiry

Figures 5 and 6 show the percent of Cohort 1 teachers who agreed or strongly agreed with statements specific to quality of the information about pedagogical strategies aimed at fostering inquiry in the classroom. Several integrated aspects of instruction are critical for effective inquiry instruction. These aspects include PBL, MBI, SEL, and connection to community-based resources. A main goal of Academy 2 was to provide teachers with high-quality information and deepen their understanding of these aspects as critical for effective inquiry instruction. The statements below inquired about the extent to which teachers agreed that Academy 2 provided high quality information and deepened their understanding of the inquiry strategies and provided high-quality content about these inquiry strategies. Similar to Figure 4, 100% of Cohort 1 teachers (12/12 teachers) either agreed or strongly agreed that Academy 2 effectively delivered high-quality information about and deepened their understanding of PBL, MBI, and SEL.

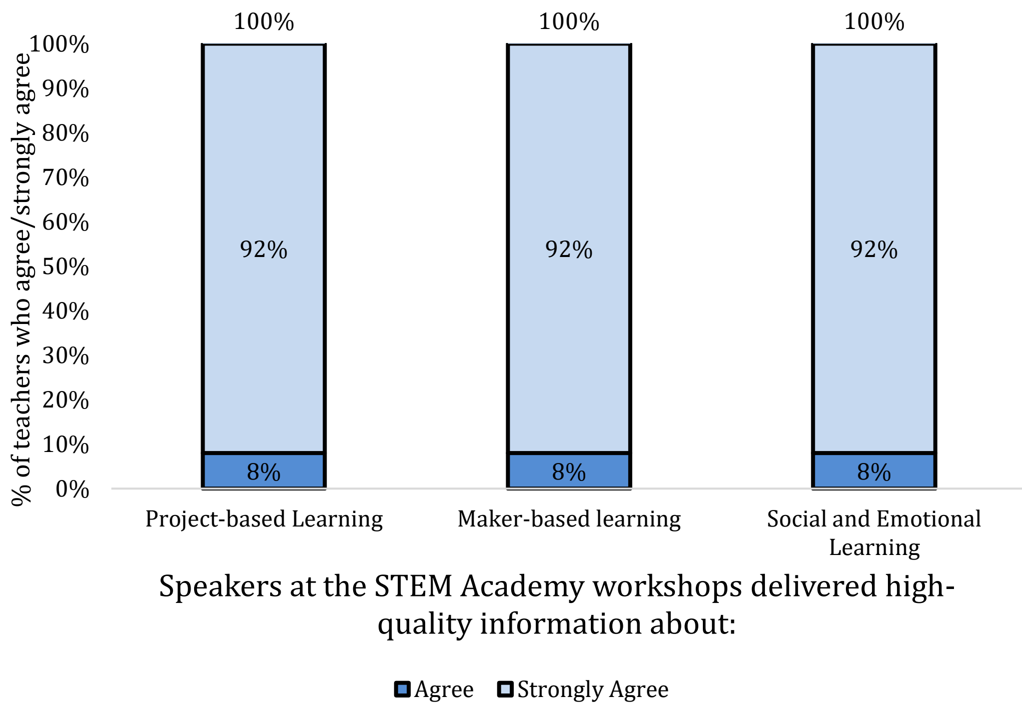

Figure 5. Percent of Teachers who Agreed or Strongly Agreed with Statements about Speakers on the Main Three Topics during Academy 2

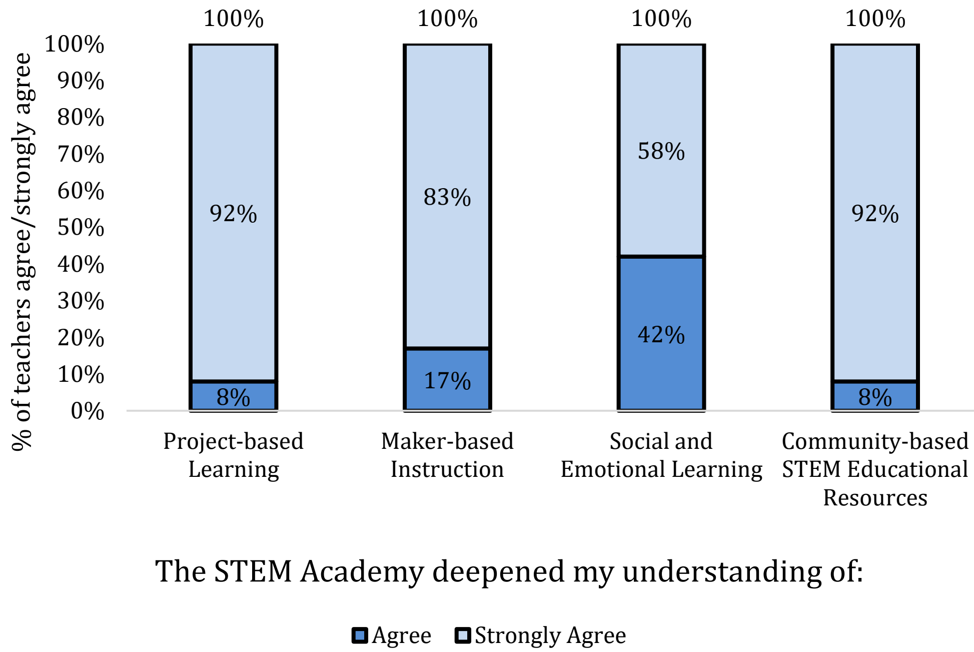

Figure 6. Percent of Teachers who Agreed or Strongly Agreed with Statements about Deepening Understanding of Pedagogical Strategies during Academy 2

On the open-ended survey items, 100% of the teachers reported that active learning strategies was the most or one of the most useful areas of the academy with six teachers explicitly referencing the 5E model, two teachers explicitly referencing PBL, and one teacher explicitly referencing MBI (one teacher referenced two of these, and one teacher referenced all three). In addition, seven of the 12 teachers specifically mentioned the word ‘inquiry’ in their answer to what was the most useful portion of the academy.

With regard to the 5E model, the teachers found identifying each of the steps valuable and one stated "learning how to ensure my lessons incorporate each part” was most useful. One teacher said she appreciated the “the deep dive into inquiry-based learning,” which was representative of the comments made by several. Another teacher noted that “the explanation and demonstration of inquiry-based learning was especially helpful.” None of the teachers mentioned any areas for improvement within the inquiry content.

Process Standards

Academy 2 focused on two main instructional strategies (i.e., PBL and MBI) because the effective implementation of these strategies requires an understanding of the scientific process standards. When these instructional strategies are integrated in the science classroom, the students are learning, practicing, and utilizing the scientific process standards. For example, PBL has the students begin by asking essential questions that are relevant to a specific group of people and then develop a solution based on a well-researched hypothesis. MBI requires students to create, and typically build, a model of an object that will serve a specific purpose, and then evaluate that model for efficacy. In addition, SEL factors into the collaboration and reporting skills espoused by STEM research and outlined in the process standards, which was woven into the two main instructional strategies throughout Academy 2. Figure 11 shows the percent of teachers who agreed or strongly agreed that Academy 2 provided them with the tools necessary to apply the principles of PBL, MBI, and SEL in their classroom. Overall, 100% of the teachers (12/12 teachers) agreed or strongly agreed with these statements. Both PBL and MBI had slightly higher percentages of teachers strongly agreeing (83%) than SEL (75%), however as mentioned above, more direct focus was given to these two strategies during Academy 2.

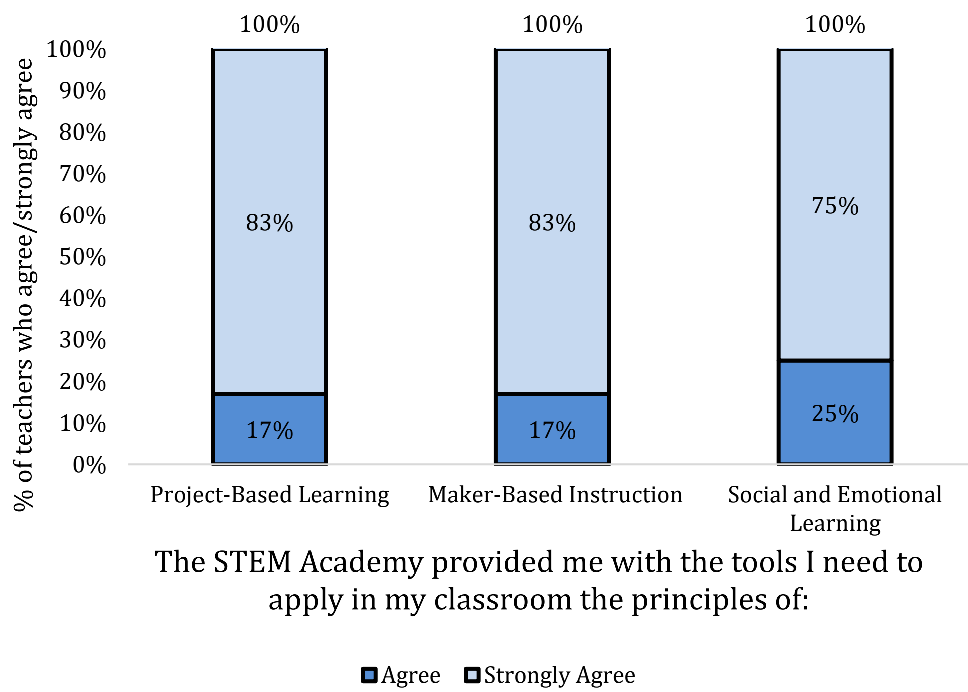

Figure 11. Percent of Teachers who Agreed or Strongly Agreed that Academy 2 Provided them with the Tools Necessary to Apply the Principles of the Three Main Strategies in their Classroom

On the open-ended items, teachers did not explicitly mention the scientific process standards as either useful or in need of improvement. However, as mentioned above, all of the teachers made favorable comments regarding inquiry instruction more broadly. Within Cohort 1, half of the teachers (6/12) specifically mentioned the 5E model favorably, which requires the use of process standards in the levels of explore and explain. In addition, three of the comments referenced either PBL or the Question Formulation Technique, both of which rely on essential questions to drive student investigation.

Content Knowledge

Figure 9 shows that 92% of Cohort 1 teachers (11/12 teachers) strongly agreed that the structure of Academy 2 enhanced their understanding of the science content. The remaining teacher (8%) disagreed with this statement.

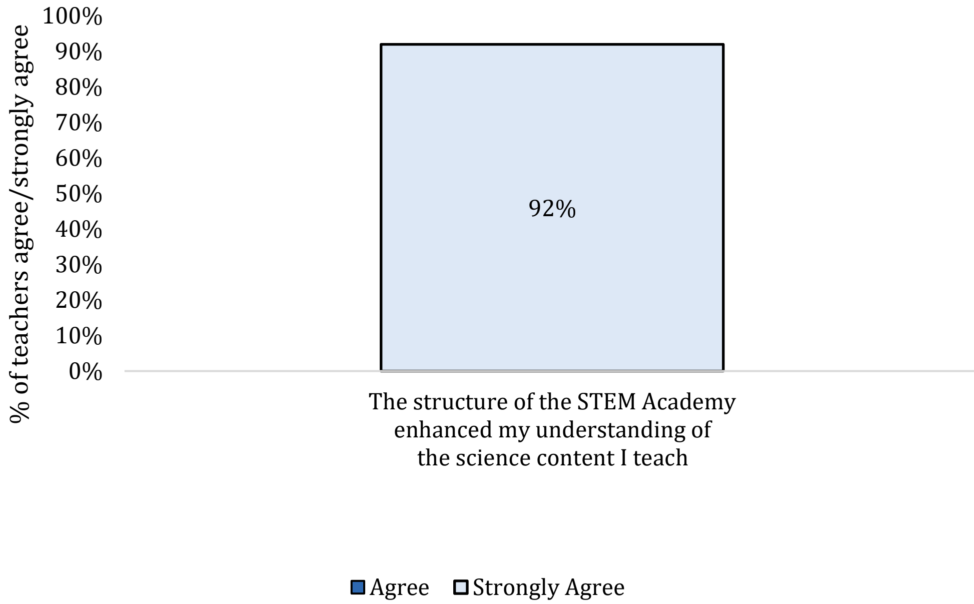

Figure 9. Percent of Teachers who Agreed or Strongly Agreed Across Years with a Statement about Content Knowledge

Figure 10 shows the teacher responses regarding the relevance of the community-based resources to the science content taught in the classroom. Each of the three experiential learning activities was designed to incorporate real world problems and careers into the scope of the science content standards. Direct connections were made between specific activities or careers and individual TEKS. Overall, Cohort 1 teachers responded most favorably toward the Frontiers of Flight Portable Planetarium. Specifically, 83% of teachers (10/12 teachers) strongly agreed that the Frontiers of Flight Portable Planetarium was relevant to the science content they taught, with the remaining 17% (2/12 teachers) agreeing with this statement. Additionally, 100% of the teachers agreed or strongly agreed that the field trip to DART headquarters and the walk STEM, talk STEM activity on the SMU campus were relevant to the science content they teach.

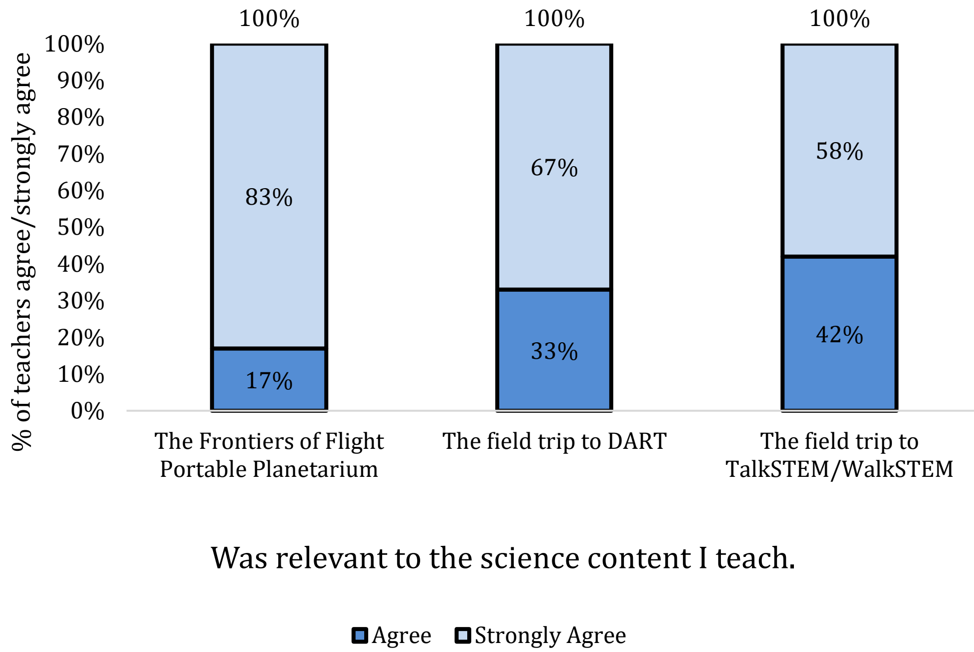

Figure 10. Percent of Teachers who Agreed or Strongly Agreed that the Community-Based Resources were relevant to the Science Content they Teach

On the open-ended response questions, teachers did not explicitly reference the content knowledge associated with Academy 2. Only one teacher mentioned content knowledge on the open-ended items, and it was in the recommendations for improvement category. The teacher recommended that the Academy 2 developers "try to ensure that most, if not all, material presented is related to science and suited for it." They elaborated that "it can be difficult to be given techniques geared for other subjects without any example of how to use [them] in science."

Differentiation and On-Going Support for Teachers

The core pillar of differentiation was addressed throughout Academy 2 as attending to diverse student needs with an emphasis on SEL, which is integral to the implementation of active learning. In order to attend to the varying needs of the student populations with whom teachers worked and address diverse contextual needs across campuses, teachers received coaching support during the school year focused on incorporating active learning, SEL, and community-based learning opportunities with their students. Figure 7 shows the percent of Cohort 1 teachers who agreed or strongly agreed that the planned on-going support and coaching would help them apply the concepts covered during Academy 2 in their classroom instruction during the upcoming school year. For each of these strategies, 92% strongly agreed that the on-going support would help them incorporate these strategies into their science curriculum.

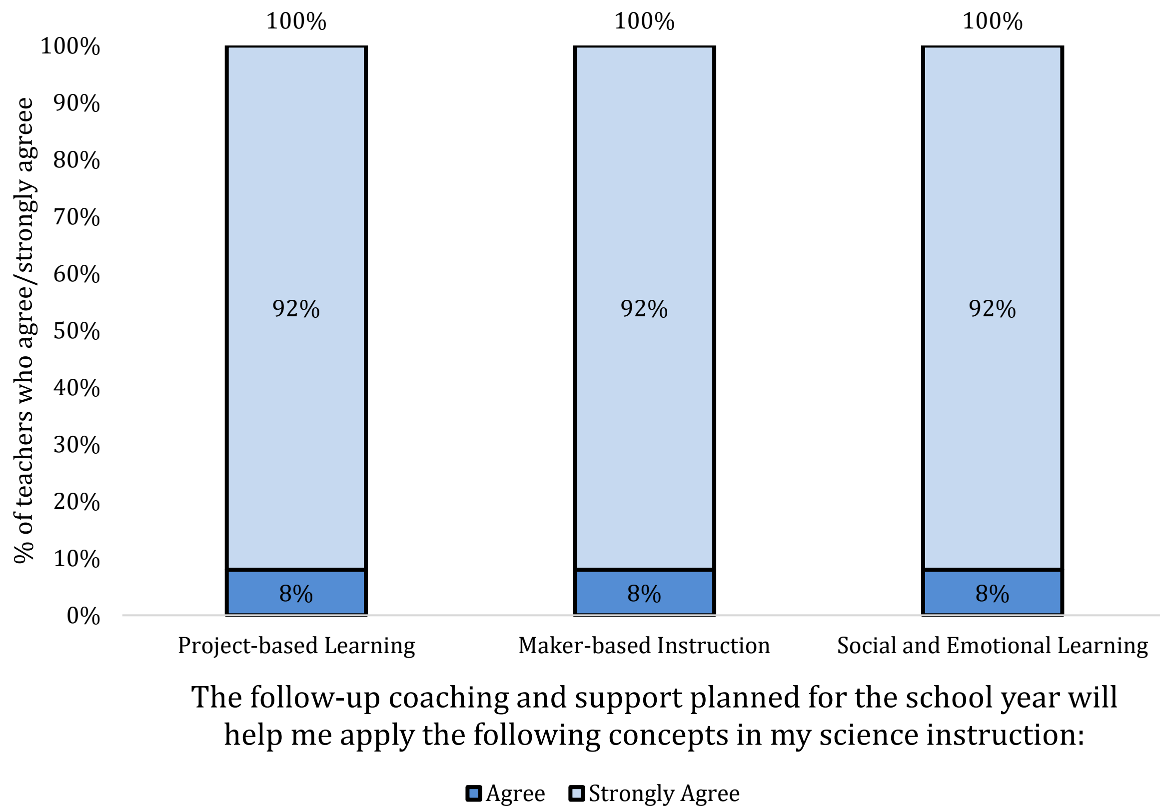

Figure 7. Percent of Teachers who Agreed or Strongly Agreed with Statements about Planned Coaching Support Helping with Classroom Implementation of the Three Main Strategies

On the open-ended questions, three of the teachers (25%) mentioned that aspects of the academy related to on-campus supports were most useful. Two of the teachers specifically made statements about collaboration listing “coaching” and “modeling for us what we will apply to our students.”

The structure of Academy 2 included one field trip to DART, an on-campus Frontiers of Flight Museum mobile planetarium presentation, and an on-campus walk STEM, talk STEM activity. These resources focused on ways to engage a variety of different learners and helped exemplify how to incorporate career readiness and local issues into science content. These activities focused on (a) deepening teachers’ understanding of community-based resources, and (b) making connections between curriculum and innovative, newly emerging careers. Much research on differentiation has been conducted over the past two decades, but “learning to cope with individual differences in student learning remains one of the more poignant issues faced by the classroom teacher” (Yates, 2000, p. 347). Incorporation of experiential learning opportunities fosters differentiation and allows students to internalize more content because “learning is driven by curiosity of the here-and-now, and anticipation of the future” (Kolb, 2014, p. 197).

Figure 8 shows the percentage of teachers responding favorably to the Flight Museum, DART, and walk STEM, talk STEM, specifically regarding their ability to use these community-based resources with their students. Ultimately, 100% of Cohort 1 teachers (12/12 teachers) agreed or strongly agreed that each of the three community-based resources they attended during Academy

2 provided ideas to supplement in-class learning, thereby addressing the needs of a variety of learners.

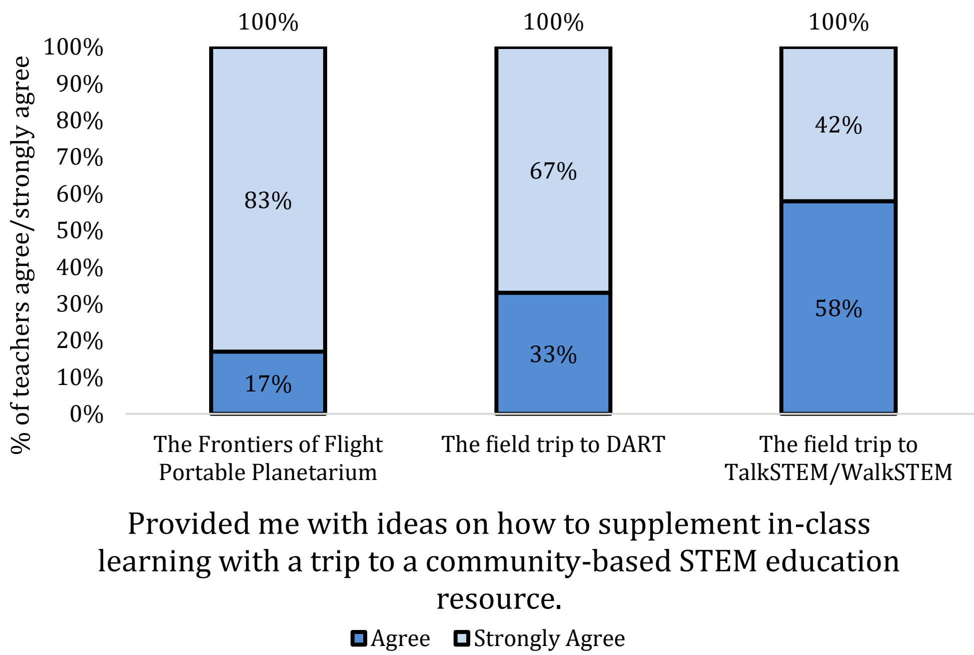

Figure 8. Percent of Teachers who Agreed or Strongly Agreed with Statements about the Community-Based Resources Providing Supplemental Ideas for Classroom Instruction

In the open responses, one teacher listed experiential learning as the most helpful for supporting differentiation saying, "I really found the community resources most useful."

Two out of the six total teachers who suggested improvements to Academy 2 indicated areas for improvement within community-based resources or support. One teacher expressed the opinion that the field trip to the planetarium and the walk STEM, talk STEM may need to be re-evaluated. This teacher stated, "I felt that the first field trip (planetarium, walk/talkSTEM) could be improved." The second teacher expressed more general interest in increased differentiation and support resources by recommending that the academy include "more social and emotional instruction learning."

Summary

Overall. All of the Cohort 1 teachers (12/12) participating in Academy 2 indicated that they strongly agreed that the academy was valuable, interactive, and that they would share their knowledge gained through this experience with their colleagues.

Academy Content. The content of Academy 2, described in detail in this report, included 90 hours of professional development. Seventy of these hours were face-to-face on or near the SMU campus. The content emphasized the integration of core active learning instructional strategies and connections to community-based STEM education resources. These core instructional strategies were connected to the foundational pillars, which included inquiry, differentiation, content knowledge, and scientific process standards. All of the teachers (12/12) strongly agreed that Academy 2 helped them improve their science instruction. Ninety-two percent of the teachers (11/12) strongly agreed that the content of the academy met their expectations, with the remaining 8% (1/12) agreeing with this statement.

Inquiry. Teachers responded favorably to questions about inquiry, with 100% (12/12) agreeing or strongly agreeing that the STEM Academy deepened their understanding of inquiry strategies including PBL, MBI, SEL, and community-based connections. One hundred percent of teachers (12/12) also agreed or strongly agreed that the speakers at the academy delivered high quality information about these different inquiry-oriented strategies. Furthermore, all of the teachers (12/12) made positive comments about the inquiry components of the face-to-face academy, with the most mentioned strategy being the 5E model.

Process Standards. In order to implement the inquiry-based pedagogical strategies presented during Academy 2, the teachers need an understanding of the process standards. These are woven throughout the implementation of the main strategies covered, and all of the teachers (12/12) agreed or strongly agreed that Academy 2 provided them with the tools required to implement the principles of PBL, MBI, and SEL in their classrooms. Since these pedagogical techniques require the use of the process standards, this indicates that the teachers were provided with tools to implement activities and lessons that incorporate and teach the process standards.

Content Knowledge. Most of the teachers (11/12) strongly agreed (92%) that the structure of the academy enhanced their understanding of the science content they teach. One-hundred percent of the teachers (12/12) agreed or strongly agreed that the community-based STEM education resources were relevant to the science content they teach. On the open-ended responses, one teacher emphasized the importance of connecting all aspects of Academy 2 to relevant science content.

Differentiation and Support. One of the primary ways that differentiation was addressed during the STEM Academy was through the on-going support planned throughout the upcoming school year which would increase the likelihood that the teachers would implement instructional strategies that inherently differentiate for learners by attending to diverse and contextualized student needs. In addition, the teachers were exposed to experiential learning opportunities that promote differentiation by engaging students in activities outside of the classroom and drawing real world connections. One hundred percent of the teachers (12/12) agreed or strongly agreed that the on-going support planned for the upcoming school year will help them implement PBL, MBI, and SEL strategies into their classrooms during the school year. One hundred percent of the teachers (12/12) also agreed or strongly agreed that the field trips provided them with ideas of how to supplement in-class learning with community-based resources.

Conclusion and Recommendations

Three recommendations for improving the Academy 2 in the future are suggested, based on the results and analysis within this report.

1. The core structure and activities within Academy 2, especially the emphasis on the 5E model, should continue with minor if any adjustments in future years. This recommendation is based on teachers' overwhelmingly positive perceptions of Academy 2. Additionally, on open ended items, six of the 12 teachers (50%) explicitly referenced the emphasis on the 5E model as one of the most helpful aspects of Academy 2.

2. The participating teachers gave positive feedback towards the DART headquarters community resource excursion, and less favorable feedback towards walkSTEM, talkSTEM. The main difference between these two community-based STEM education resources was that the DART headquarters outing was highly structured and delivered by experts; whereas, the first field trip day was more relaxed in schedule and offered ideas that the teachers would then need to modify in order to implement them in the classroom. It is therefore recommended that the content delivered during field trips be directly applicable to classroom use, highly structured, and delivered by experts in the field.

3. While the online portion of the academy was acknowledged by both participating teachers and SMU staff as an appropriate mechanism for covering more content while maintaining a reasonable number of face-to-face contact hours, the teachers noted that the time predictions given were not always accurate, and tended to underrepresent how much time was needed. Since this was the first iteration of Academy 2, the development team assigned predicted time lengths, but evidence shows that either these should be extended in order to give the participating teachers a more accurate idea of how long they need to allot for each activity or modifications should be made to the online curriculum to shorten the time needed to complete activities.

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Appendix A – Presenter Biographies

John H. Easton: Dr. John Easton is a lecturer working with the Department of Civil and Environmental Engineering at Southern Methodist University. John graduated from the School of Electronic, Electrical and Computer Engineering at University of Birmingham in 2004 with a MEng in Computer Systems Engineering with Management. He then went on to spend five years in the same School working on his PhD, which was co-supervised by the School of Biosciences and Birmingham Children's Hospital. He graduated again in 2009.

Robyn Hartzell: With over 19 years of experience as an educator, Robyn Hartzell serves in a variety of roles including teacher, instructional coach, interventionist, trainer, and consultant. She was a classroom teacher for eight years before moving into an interventionist/coaching position. After eleven years of teaching and coaching, Robyn transitioned to the role of Consultant, then Program Coordinator for the second largest Educational Service Center in the state of Texas. While there, she developed and provided training for K-12 teachers and instructional coaches in public, private, and charter schools.

DiMitri Higginbotham: DiMitri Higginbotham is a graduate student at Southern Methodist University where he is working on an M.A. in Design and Innovation, focusing on maker education and human-centered design strategies. He is the graduate assistant for the SMU Maker Education Project, where he drives and teaches from the SMU Maker Truck.

Katie Krummeck: Katie Krummeck got her Bachelor of Arts in American Studies from Whitman College. Katie worked to implement design thinking in K-12 education at the Hasso Plattner Institute for Design (d.school) at Stanford University, and then led the implementation of the SparkTruck project, a mobile makerspace for children. She then became the director of the Deason Innovation Gym at the Lyle School of Engineering at SMU, and then became the Director for the SMU Maker Education Project. Katie is now the Director of Programs for the Construct Foundation in Portland, Oregon.

Alain Mota: Alain Mota is the STEM Development and Implementation Coordinator at RME. In this role, he supports campus leaders and science teachers in the delivery of classroom lessons that focus on the integration of STEM and active learning techniques through individualized coaching, co-planning and facilitating Professional Learning Communities, and feedback following classroom observations. This role is part of SMU's STEM Academy for Science Teachers and Leaders initiative, intended to increase student achievement in science, student interest in STEM and students' persistence in STEM coursework by supporting teachers' professional knowledge and skills, and campus administrators' instructional leadership skills.

Karen Pierce: Karen Pierce earned her bachelor's degree in biology and master's degree in teaching from Austin College. She then taught high school science in New Mexico for eight years. During that time, she taught a wide variety of courses including biology, physics, AP chemistry, genetics, microbiology, and pharmacology. Karen's academic interests include curriculum design and vertical alignment. She is currently working towards her Ed.D. in Higher Education from SMU, with a planned completion date of May 2021.

Rob Rouse: Dr. Rob Rouse joined SMU's School of Education after completing his Ph.D. in Mathematics and Science Education at Vanderbilt University's Peabody College. At Vanderbilt, Rob worked with pre-service and in-service teachers in various contexts, including as a graduate teaching assistant, university field mentor, and course co-instructor. Prior to pursuing his doctorate, Rob taught high school chemistry for four years at a performing arts high school in New York City as a member of the New York City Teaching Fellows. Rob's research focuses on the intersection of science and engineering by investigating how design-based learning environments engage students in approximations of the epistemic practices of scientists and engineers. He is currently a Clinical Assistant Professor at SMU.

Erica Simon: Erica Simon is the Assistant Director for Strategic Development & Partnerships for the Research in Mathematics Education (RME) research unit. Her emphasis is on developing research, practitioner, and community partnerships to support RME's mission while being highly focused on access and equity for all children in mathematics. Erica joined SMU in August of 2009 as an observer on the Early Learning in Mathematics (ELM) study and returned to SMU in 2012 to join RME. Erica participates in grant writing teams, disseminates RME research and development findings at state and national conferences, and promotes RME outreach through leading the coordination team for the annual Research-to-Practice Conference.

Juan Torralba: Juan Torralba is currently a doctoral student at University of Miami. Juan began his Ph.D. in Teaching in Learning in STEM Education in August 2016. Juan received his Bachelor of Business Administration from University of North Texas in 2013 and received his M.Ed. from SMU in 2016. After completing his M.Ed, Juan was a research assistant for Lyle School of Engineering's Deason Innovation Gym. At University of Miami, Juan is a graduate research assistant in the School of Education's STEM Department. His research focuses on building students' critical thinking and social-emotional skills through applied challenges that extend beyond the classroom.

Appendix B – Academy 2 Teacher Evaluation Survey

To what extent do you agree with the following statements?

	Strongly Disagree	Disagree	Agree	Strongly Agree
1. The STEM Academy was a valuable professional development opportunity.				
2. The STEM Academy deepened my understanding of: o Project-based learning o Maker-based instruction o Social and emotional learning o Community-based STEM education resources				
3. The STEM Academy provided me with the tools I need to apply in my classroom the principles of: o Project-based learning o Maker-based instruction o Social and emotional learning				
4. The knowledge I gained at the STEM Academy will help me improve my science instruction.				
5. The content of the STEM Academy met my expectations.				
6. The structure of the STEM Academy enhanced my understanding of the science content I teach.				

7. The follow-up coaching and support planned for the school year will help me apply the following concepts in my science instruction: ○ Project-based learning ○ Maker-based instruction ○ Social and emotional learning				
8. The Frontiers of Flight Portable Planetarium was: ○ was relevant to the science content I teach. ○ provided me with ideas on how to supplement in-class learning with a trip to a community-based STEM education resource.				
9. The field trip to DART: ○ was relevant to the science content I teach. ○ provided me with ideas on how to supplement in-class learning with a trip to a community-based STEM education resource.				
10. The field trip to TalkSTEM/WalkSTEM: ○ was relevant to the science content I teach. ○ provided me with ideas on how to supplement in-class learning with a trip to a community-based STEM education resource.				
11. I will share the knowledge I gained from the STEM Academy experiences with my colleagues.				
12. Speakers at the STEM Academy workshops delivered high-quality information about: ○ Project-based learning ○ Maker-based instruction				

o Social and emotional learning				
13. The STEM Academy was interactive.				

14. What areas of the STEM Academy were most useful to you?

15. Which areas of the STEM Academy need improvement?

16. Is there anything else you would like to share about the STEM Academy?