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Research in Mathematics Education

STEM Academy for Teachers and Leaders: 2017 Academy Evaluation

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STEM Academy for Teachers and Leaders: 2017 Academy Evaluation

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Executive Summary

The STEM Academy for Science Teachers and Leaders project is a partnership between Southern Methodist University and Dallas Independent School District (ISD) and is funded by the Texas Instruments Foundation and the O'Donnell Foundation. The proposed outcomes of this four-year project include:

- An increase in student achievement, attainment of the process standards, and engagement in mathematics and science to support the continued pursuit of STEM-focused studies
- An increase in teacher ability to implement active learning experiences to support student learning
- An increase in teacher leadership skills and capacity to mentor new teachers
- An increase in teacher skill and mindset to support professional growth

To reach these outcomes, teachers and leaders from Dallas ISD participate in an intensive in-person professional development academy during the summer; engage in online professional development in the summer, fall, and spring; and receive in-person coaching throughout the school year.

The first STEM Academy for Science Teachers and Leaders was conducted in June 2017 and consisted of 90 hours of professional development. Teachers participated in 70 hours of face-to-face coursework on the SMU campus. Prior to and after the face-to-face learning, teachers collaborated and participated in online modules on Canvas, an online course delivery system. Teachers spent 20 hours learning through the online modules.

In keeping with the goals of the project, the STEM Academy for Science Teachers and Leaders focused on inquiry-based instruction, scientific process standards, teacher content knowledge, and differentiated support for all learners, including English Learners, Students with Disabilities, and Gifted and Talented students. Building on current research in STEM education, Maker-Based Instruction (MBI) and Project-Based Learning (PBL) were selected as the inquiry-based pedagogical approaches for the STEM Academy. In addition to MBI and PBL, instruction was also provided on Geographical Information Systems (GIS) and Social and Emotional Learning (SEL). Within the face-to-face portion of the STEM Academy, teachers also learned about community-based STEM educational resources by participating in field experiences to the Dallas Zoo and the Trinity River Audubon Center.

Sixteen teachers from six Dallas ISD middle schools participated in the first STEM Academy for Science Teachers. At the completion of the STEM Academy for Science Teachers and Leaders, teachers were asked to provide feedback on a survey, the *STEM Academy for Teachers and Leaders: Academy Evaluation*, about their beliefs and experiences at the STEM Academy. Thirteen teachers completed the survey.

Every teacher (100%; 13/13) agreed or strongly agreed that the STEM Academy was a valuable professional development opportunity and that the knowledge gained at the STEM Academy would help them improve their science teaching. This belief is supported by the fact that all

teachers noted that they would be sharing the knowledge gained at the STEM Academy with their colleagues.

Overall, the structure and content of the STEM Academy also met teachers' expectations. 77% (10/13) of teachers agreed that the structure of the STEM Academy enhanced their understanding of the science content they teach. Additionally, 85% (11/13) of teachers agreed that the content of the STEM Academy met their expectations. All teachers agreed that the STEM Academy was interactive, with 69% (9/13) strongly agreeing. Overwhelmingly, teachers' responses indicated that the presenters delivered high-quality information. All teachers (100%; 13/13) agreed that the speakers presented high-quality information about MBI and SEL, while 92% (12/13) and 85% (11/13) said the same about PBL and GIS, respectively.

The teachers also noted positive experiences with the two community-based STEM education resources (i.e., Dallas Zoo, Trinity River Audubon Center) visited during the STEM Academy. 85% (11/13) of teachers agreed that these visits provided them with ideas on how to supplement in-class learning with a trip to a community-based STEM educational resource, and 92% (12/13) of teachers agreed that the community-based STEM education resource was relevant to the science content they teach.

The results from this survey also indicate that teachers' knowledge increased as a result of the STEM Academy. All teachers (100%; 13/13) said that their knowledge of Project Based Learning, Maker Based Instruction, and SEL deepened during the STEM Academy. The majority of teachers also felt their knowledge of community-based STEM educational resources and GIS deepened [92% (12/13) and 85% (11/13), respectively].

The teachers also noted that they felt equipped with the tools needed to apply the principles from the STEM Academy in their classrooms. All teachers (100%; 13/13) either agreed or strongly agreed that they were provided the tools needed to apply PBL, MBI, and SEL principles in their classrooms. The majority of teachers (85%; 11/13) also felt equipped to apply GIS in their classrooms. This is particularly positive since the majority of teachers reported having very little previous professional development on these topics prior to the STEM Academy [i.e., 44% (7/16), 81% (13/16), and 88% (14/16) of teachers had experienced no professional development in the past year on PBL, MBI, and GIS, respectively].

While the majority of teachers felt equipped after the STEM Academy, all teachers (100%; 13/13) agreed that the follow-up coaching planned during the school year would help them apply PBL and MBI in their instruction. 92% (12/13) of teachers noted the follow-up coaching would assist them in applying GIS content and principles of SEL.

In summary, these results suggest that teachers had a positive experience at the STEM Academy, deepened their knowledge of PBL, MBI, SEL, and GIS, and feel equipped to apply these principles in their classrooms.

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STEM Academy for Teachers and Leaders: 2017 Academy Evaluation

Background

The number of jobs requiring science, technology, engineering, and mathematics (STEM) in the U.S. is far outpacing the predicted growth rate for other jobs, at 17% and 10%, respectively. According to the National Math and Science Initiative, nearly one million additional STEM graduates will be needed over the next decade in order to meet the United States' demand.

In 2013, House Bill 5 (HB 5) was passed by the Texas Legislature, which required that students entering high school select an endorsement area, including STEM, Business and Industry, Public Services, Arts & Humanities, and Multidisciplinary Studies. The endorsements, or pathways, were implemented in the 2014-2015 school year, and since that time, just 16.9% of Dallas ISD students have selected the STEM pathway.

These troubling statistics, coupled with SMU's history of collaboration with Dallas ISD fostered early conversations with the Texas Instruments Foundation, led by former Simmons Dean David Chard, Dr. Leanne Ketterlin Geller, Dr. John Stolk, and Dallas ISD's Vincent Reyes 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 (1) inquiry-based instruction, (2) scientific process standards, (3) teacher content knowledge, and (4) differentiated support for all learners, including English Learners, Students with Disabilities, and Gifted and Talented students.

Through these conversations, a framework of desired outcomes was determined that would help initiate and refine the goals of this projected 4-year project. These outcomes include:

- An increase in student achievement, attainment of the process standards, and engagement in mathematics and science to support the continued pursuit of STEM-focused studies
- An increase in teacher ability to implement active learning experiences to support student learning
- An increase in teacher leadership skills and capacity to mentor new teachers
- An increase in teacher skill and mindset to support professional growth

Overview of the STEM Academy for Teachers and Leaders Project

The STEM Academy for Science Teachers and Leaders project is intended to impact 70 percent of the middle school science teachers by the fourth year of the project. The teacher support for the project was developed to include three phases.

- *Phase I* focuses on inquiry-based instruction, scientific process standards, teacher content knowledge, and differentiated support for all learners through intensive summer academies, each with 90 contact hours of graduate-credit instruction. The first STEM Academy was conducted in the summer of 2017 with modules in Maker-Based Instruction, Project-Based Learning, Geographic Information Systems, and Social and Emotional Learning.

- *Phase II* of the project emphasizes sustainability and implementation of inquiry-based instruction, scientific process standards, teacher content knowledge, and differentiated support for all learners. This is achieved through regular onsite coaching and observation from SMU staff, monthly Professional Learning Communities (PLCs) conducted at the schools and led by school leadership, as well as ongoing collaboration between the teacher cohort to gain pedagogical and design skills to develop their own active learning experiences.

- Finally, *Phase III* of the project measures and assesses teachers' implementation of inquiry-based instruction, scientific process standards, content knowledge, and differentiation for all learners.

At each participating campus, a Science Campus Instructional Leader (SCIL) also engaged in the project. The SCIL is critical to the project because he/she works collaboratively with the SMU staff to support the teachers during the academic year as they grow professionally, study pedagogy and content, self-reflect, implement change, grow as leaders, and impact students' understanding of STEM. The leader support for the project was developed to include two phases.

- *Phase I* focuses on the leaders' understanding of inquiry-based instructional practices, anticipating, brainstorming, and problem solving possible stumbling blocks teachers may face as they change instructional practices. The first academy was conducted in the summer of 2017 and provided 35 contact hours of professional development.

- *Phase II* focuses on sustainability of implementation. This phase is supported through regular onsite coaching for the leaders. The onsite coaching is designed to support the leaders in growing their capacity for effective PLCs and also provides them with a resource (SMU Staff) to reflect with and seek input from as challenges arise during implementation.

Purpose of this Report

This report details an evaluation of *Phase I* for the first cohort of teachers participating in the STEM Academy for Teachers and Leaders. As noted, while leaders participated in a summer STEM Academy, this report focuses only on the teacher STEM Academy and their experiences. This report includes information about the content and structure of the STEM Academy as well the teachers participating in the STEM Academy and details the results from an evaluation survey completed by the teachers at the end of the STEM Academy.

Content and Structure of the STEM Academy for Teachers and Leaders

The SMU project team designed the content and structure of the STEM Academy to meet the goals and objectives of the project and align with the needs and constraints of instructional leaders and science teachers. To facilitate collaboration, the SMU project team met monthly with representatives from DISD's STEM curriculum department and the research and evaluation department.

In keeping with the goals of the project, the STEM Academy focuses on inquiry-based instruction, scientific process standards, teacher content knowledge, and differentiated support for all learners. Building on current research in STEM education, Maker-Based Instruction (MBI) and Project-Based Learning (PBL) were selected as the inquiry-based pedagogical approaches for the STEM Academy.

MBI has two components: proficiency and purpose. MBI requires developing proficiency using a tool. Then that tool is used for a purpose – to make something that solves a problem or answers a question. MBI is hands-on, student-directed, iterative, and does *not* have a pre-determined outcome. Variability of outcomes is key.

PBL is organized around a central, driving question. Students work collaboratively to answer an authentic, STEM-related question. The driving question is broad enough to cover a variety of instructional standards. Students lead the project by asking more questions, testing hypotheses, conducting research, and designing and carrying out experiments. Assessment is embedded throughout PBL units, formally and informally. Often, the final artifact (e.g., PowerPoint, poster, product, video, infographic) is presented to peers, educators, and outside experts.

Participants received concentrated professional development, which is explained in additional detail in the next section, on these approaches. Teachers also generated instructional units that employ these approaches to teach high-priority TEKS. The instructional units will be delivered during the 2017-18 academic year.

To meet the practical constraints of the science teachers, the SMU project team conducted a portion of the STEM Academies online and 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 June 2017, and 20 hours learning through the online modules.

In addition to MBI and PBL, instruction was also provided on Geographical Information Systems (GIS) and Social and Emotional Learning (SEL).

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 at the Dallas Zoo and the Trinity River Audubon Center. Additional information on the topics from the STEM Academy and the community-based educational resources is included below.

Activities within the STEM Academy for Teachers and Leaders by Content Area

This section outlines the activities conducted for each of the primary content areas. The online modules included instruction on MBI and PBL. The face-to-face modules included instruction on MBI, PBL, SEL, GIS, and community-based STEM educational resources. Information on the presenters for each of these content areas can be found in Appendix A. A reference list for the Academy can be found in Appendix B.

Maker-Based Instruction

During the *pre-academy online module*, participants started by sharing their prior knowledge of MBI through a self-made video and a drawing. Most participants remarked that they did not know very much about MBI prior to the start of the STEM Academy for Teachers and Leaders. They all indicated their excitement and eagerness to learn. Next, they watched videos, listened to TED Talks, and read research articles about the people (makers), places (makerspaces), and activities (making) that constitute MBI. This section ended with two interactive discussions about MBI focusing on the participants' initial reactions to the literature on MBI and how MBI might connect to their own students and content areas.

In the *face-to-face portion* of the STEM Academy, participants deepened their understanding of makerspaces by visiting the Deason Innovation Gym (DIG) in the Lyle School of Engineering and a mobile makerspace (formerly known as the SparkTruck). The DIG is a student-centered 24/7 makerspace open to all SMU students that contains low-tech and high-tech materials, such as laser cutters, 3D printers, and common objects, and the mobile makerspace truck is a nationally-recognized vehicle that originated at Stanford. Through these experiences, teachers learned that MBI tools can be as complex as a 3D printer or as simple as a glue gun. The spaces can be as elaborate as the DIG or as modest as a card table with supplies.

Before launching a mini unit of instruction, the facilitators, Katie Krummeck and Dr. Rob Rouse, provided an overview of MBI, including the postures and roles of students and teachers, examples of MBI, and the three modes of an MBI sprint (i.e., exploration, skill-building, challenge). The participants learned about the exploration, skill-building, and challenge modes in the context of a transportation-themed "sprint." The teachers thought about their own commutes to work and traffic congestion in the DFW metroplex. During the exploration mode, teachers used clay to model creative, hybrid vehicles that could help relieve some of the issues commuters currently face. Next, during the skill-building phase, teachers learned how to use TinkerCAD, a 3D computer-aided design (CAD) tool. Lastly, teachers used the technological tool to digitally model their vehicles during the challenge phase.

The final part of the face-to-face MBI coursework was dedicated to understanding and executing the planning of a sprint. Teachers received several planning documents and were given time to work with the teachers from their schools to plan an MBI project focused on high-priority Texas Essential Knowledge and Skills (TEKS) identified by Dallas ISD. For example, one project focused on ecological succession and used GIS as the primary tool. Teachers presented their projects to their peers and received feedback through Canvas.

During the *post-academy online module*, participants submitted a reflection video and makerspace drawing, similar to the assignments they completed during the pre-academy online module, using the knowledge they gained during the STEM Academy. Teachers also watched more videos and read more articles that reiterated some of the topics from the face-to-face academy, including makerspaces, tools and materials, the role of the teacher, assessments, and maker mindsets. Lastly, teachers submitted a detailed one-page plan for how to implement an MBI experience, using their work from their own presentations or the information provided during the STEM Academy.

Project-Based Learning

During the *pre-academy PBL online module*, participants were introduced to PBL through several articles and videos. Specifically, they learned about the 5 keys to PBL: 1) establishing real-world connections, 2) connecting to rigorous content, 3) structuring student collaboration, 4) facilitating student-driven learning, and 5) embedding assessment throughout PBL units. Participants learned about the essential question, which drives the unit and situates it in an inquiry context. After identifying high-priority TEKS and learning about the basic structure of PBL, teachers collaborated and brainstormed ideas for PBL units that were later refined and adapted during the face-to-face STEM Academy.

In the *face-to-face portion* of the STEM Academy, teachers started with a day of physics and rocketry instruction led by Dr. Paul Krueger. Teachers worked out mathematical equations on the whiteboard to determine information about angles, mass, and acceleration. The teachers then built rockets, which they launched from the SMU campus near the Annette Caldwell Simmons School of Education & Human Development. In addition to the STEM Academy participants and SMU staff, Dallas ISD officials, Al Día, and Dallas Innovates were all in attendance. The rockets reached heights of up to 200 meters. During the rocket lessons and launch, the teachers took on the role of students, learning and engaging in the material.

Next, Robyn Hartzell led the PBL planning sessions. She exposed teachers to several planning documents, explained how to write an essential question for a PBL unit, and modeled several important protocols, like “Tell, Ask, Give” (TAG) and “critical friends” circles that encourage students to give and receive feedback in a collaborative manner. Teachers were tasked with developing PBL units of instruction. They used their brainstorm documents from the pre-academy online module, as well as the new templates provided by Robyn. The topics chosen covered a variety of TEKS: force and motion, atoms and energy, and plate tectonics. One group presented a hybrid MBI-PBL unit based loosely on the Amazon Prime Air drone. They posed a question about designing a more effective and efficient drone to deliver goods to customers. Teachers presented their projects to their peers and received feedback immediately after the presentations and through Canvas.

During the *post-academy PBL online module*, the teachers developed a calendar that corresponded to the PBL project that the teachers from their school selected. They also completed two additional assignments that emphasized the culture of an inquiry-based classroom. Teachers wrote about and created action plans around implementation of some of the effective strategies taught in the PBL and SEL face-to-face sessions.

Social and Emotional Learning

SEL involves the processes through which adults and children develop social and emotional competencies in five areas:

- Self-awareness—knowing your strengths and limitations
- Self-management—being able to stay in control and persevere through challenges
- Social awareness—understanding and empathizing with others
- Relationship skills—being able to work in teams and resolve conflicts
- Responsible decision-making—making ethical and safe decisions

During the SEL training during the *face-to-face portion* of the STEM Academy, Dr. Dara Rossi facilitated instruction for teachers to know, understand, and apply SEL techniques in the middle-school classroom. The teachers engaged with activities that allowed them to understand the adolescent brain and its response to stimuli. After addressing specific areas that pertain to teaching and learning, Dr. Rossi exposed teachers to activities and exercises that could be imbedded as part of their daily, culture-building practice. The activities ranged from creating a response based on a pictorial representation, to practicing communication skills, to solving several situational tasks. The teachers developed their knowledge of the structures and systems used in SEL, and discussed how to implement these strategies in their own classrooms.

Geographic Information Systems

GIS uses software to gather and layer geographic information into engaging and interactive maps. In education, these maps can be used to teach specific content, like plate tectonics, or to help situate students and provide contextualization.

During this session during the *face-to-face portion* of the STEM Academy, Roger Palmer introduced GIS and how the use of interactive maps can be effective for teaching middle-school science TEKS. Roger led a mini-lesson on topography using maps and live images from state parks in California. The participants explored the online mapping platform, Arc GIS, layering data and mining for interesting resources. Then, teachers deepened their knowledge of GIS by looking at topographical maps using the Esri GeoInquiries™ collection for Earth Science.

Community-based STEM Educational Resources

Teachers in the STEM Academy learned about two community-based STEM educational resources by participating in two field experiences. During the first week of the face-to-face portion of the STEM Academy, they went to the Dallas Zoo. The second week of the STEM Academy, teachers went to the Trinity River Audubon Center. The purpose of these field experiences was to deepen teachers' understanding of the power of informal learning, while also exposing them to possible field trips for their own students. The specific learning goals were for teachers to:

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

Dallas Zoo

The Dallas Zoo's three tenets are: conservation, animal welfare, and education. The 106-acre zoo embeds this mission in every aspect of their various learning modules that spans early childhood education, homeschool education, classroom programs, family programs as well as educator workshops.

At the zoo, the teachers began their morning with an introduction to scientific journals and observed various animals in their habitats. Taxonomic classification utilizing cladograms were used throughout the day as an observation tool as teachers recorded animals within the herpetarium, raptor enclosure, fish and wildlife facility, and chimpanzee habitat. A variety of TEKS were covered, including those on biodiversity, relationships in an ecosystem, and environmental changes and impacts on the environment. Several of the scientific practices in the TEKS, such as selecting appropriate tools and using evidence, were incorporated into the Zoo field experience.

Trinity River Audubon Center

The Trinity River Audubon Center sits on 120 acres within the 6,000-acre Great Trinity Forest. This reclaimed sanctuary is now home to a tremendously diverse population of birds and other wildlife within a unique environment of bottomland hardwoods, wetlands, and grasslands. The mission of the organization is "conserve and restore natural ecosystems, focusing on birds, other wildlife, and their habitats for the benefit of humanity and the Earth's biological diversity." By preserving this open space and protecting wildlife, the TRAC engages people in conservation through learning and exploration.

During this field experience, teachers kayaked on the Trinity River, explored water quality and conservation, performed a pond investigation, identified macro-organisms in a local body of water, and engaged in an animal encounter with a Pig-Nosed snake. A wide variety of organism and environment TEKS were covered, including those involving biotic and abiotic factors, variation within a population or species, adaptations, heredity, relationships in an ecosystem, and environmental changes and impacts on the environment.

Participating Teachers in Cohort 1

Sixteen teachers from six Dallas ISD middle schools participated in the STEM Academy for Teachers and Leaders. This section includes teachers' demographic information and information on teachers' career experiences, education, and previous professional development activities.

Teacher Demographic Information

Demographic information about the participating teachers is summarized in Table 1. The majority of teachers identify as female. Male teachers make up 25% of the cohort. The majority of the teachers identify as Black, followed by White and then Hispanic. No teachers identify as Alaska Native, Asian, Native Hawaiian, or other Pacific Islander.

Table 1. Teacher demographic information

		Number of Teachers	Percentage
Gender	Male	4	25%
	Female	12	75%
Race	Alaska Native	0	0%
	Asian	0	0%
	Black	9	56%
	Native Hawaiian	0	0%
	Other Pacific Islander	0	0%
	White	7	44%
Ethnicity	Hispanic or Latino	4	25%
	Not Hispanic or Latino	12	75%

Teacher Experience

On average, the teachers participating in the STEM Academy for Teachers and Leaders have been in education and teaching science for 5 – 6 years and have been at their current school for an average of 4 years (see Table 2). Many of the teachers have also had previous professional careers. The participating teachers have had approximately an average of 8 years in other careers.

Table 2. Teachers' work experience

	Mean (*SD*)
Years in education	5.7 (4.7)
Years teaching	5.5 (4.8)
Years teaching science	5.2 (4.8)
Years in other careers	7.8 (6.6)
Years at current school	4.0 (3.1)

Teacher Education and Certification Information

All teachers have Bachelor's degrees, with Biology as the most common major (see Table 3 for additional majors). Teachers also have degrees in other STEM fields, such as Mathematics, Biochemistry, and Environmental Analysis. While the majority of the teachers have degrees in STEM fields, many of the teachers do not and have degrees in English, Psychology, or Mass Communication, for example. One-fourth of the teachers also hold Master's degrees.

Table 3. Major for participating teachers' Bachelor's degrees

Bachelor's Degree	Number of Teachers
Applied Arts & Sciences	1
Biochemistry	1
Biology	6
Business Administration	1
English	1
Environmental Analysis	1
Interdisciplinary Studies	1
Kinesiology	1
Mass Communication	1
Mathematics	1
Psychology	1

The teachers also hold a variety of teaching certifications. Six teachers (37.5%) hold two or more certifications, while 62.5% of the teachers hold a single subject-area certification (see Table 4).

Table 4. Number of certifications for participating teachers

Certifications	Number of Teachers
1 subject-area certification	10
2 subject-area certifications	5
3 subject-area certifications	1

The number and types of teaching certifications can be seen in Figure 1. The most common certification is Science for Grades 4-8, while the second most common certification is Generalist for Grades 4-8. Approximately 69% of the teachers hold science certifications of some kind, while 31% hold generalist certifications and do not hold science certifications. (Since some teachers hold more than one certification, there are more than 16 data points in Figure 1.)

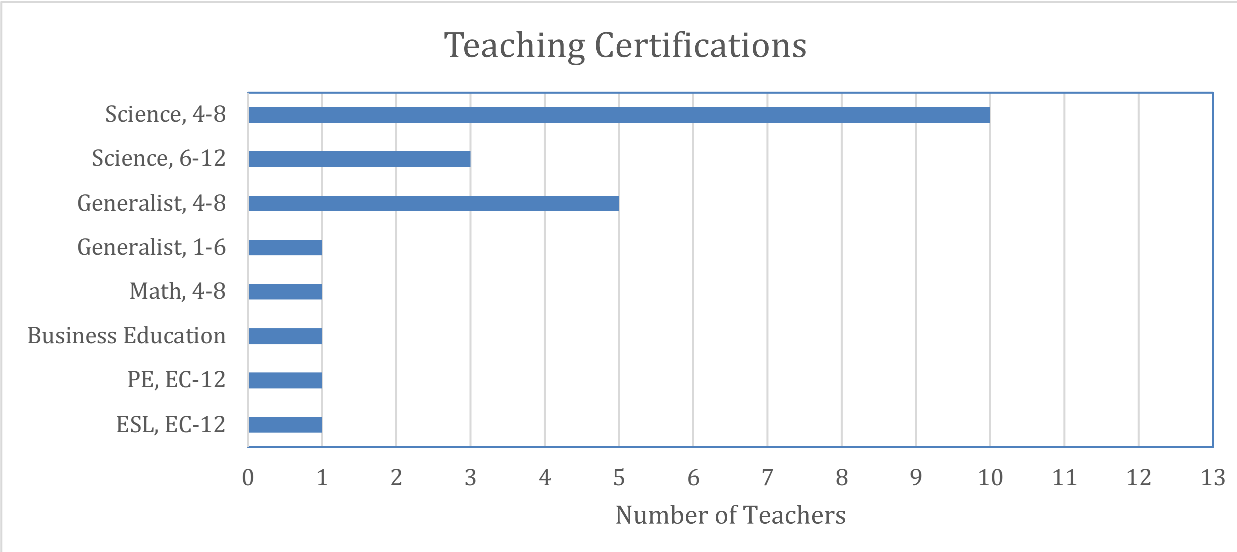


Figure 1. Number and types of teaching certifications for participating teachers.

Previous Professional Development

The teachers had all participated in previous science professional development and professional development on other topics.

Prior to the STEM Academy for Teachers and Leaders, all teachers spent time on in-service education related to science content in the past year (see Figure 2 and Table 5). All but one teacher, or 93.5%, spent over 6 hours on science-related professional development. Half of the teachers also spent over 6 hours in professional development for other content areas.

While all of the teachers had participated in some form of science professional development, most teachers had not participated in professional development on PBL, MBI, or GIS, three of the primary components covered in the STEM Academy for Teachers and Leaders (see Figure 2 and Table 5). For example, approximately 44%, 81%, and 88% of teachers experienced no professional development on PBL, MBI, or GIS, respectively. Even for teachers who experienced professional development in these areas, their encounters were short. Approximately 75% spent less than six hours on PBL, 93.75% spent less than six hours on MBI, and 100% spent less than six hours on GIS.

Table 5. Science professional development by topic

Topic	None	Less than 6 Hours	6-15 Hours	16-35 Hours	More than 35 Hours
Science content	0	1	8	2	5
Project-Based Learning	7	5	3	1	0
Maker-Based Instruction	13	2	1	0	0
Geographic Information Systems	14	2	0	0	0
Other content areas	3	5	6	0	2

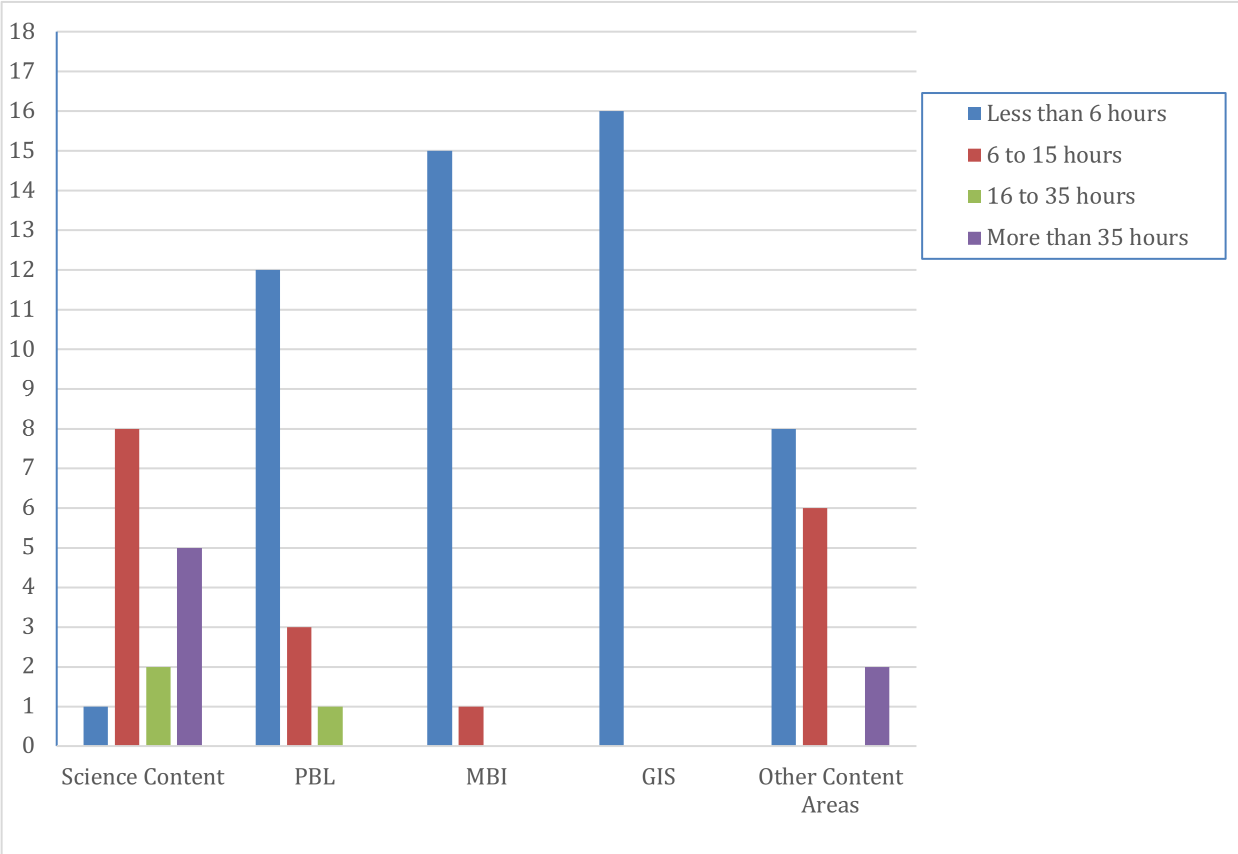


Figure 2. Science professional development by topic.

Teachers also had varied levels of previous professional development on SEL, students with disabilities, and English-language learners (see Table 6 and Figure 3). Approximately 88% and 94% of teachers had less than six hours of professional development in the past year on SEL or students with disabilities, respectively. However, over half of the teachers had received over 16 hours of professional development on English-language learners.

Table 6. Professional development by topic

Topic	None	Less than 6 Hours	6-15 Hours	16-35 Hours	More than 35 Hours
Social and Emotional Learning	6	8	1	1	0
Students with disabilities	6	9	1	0	0
English-language learners	2	5	0	8	1

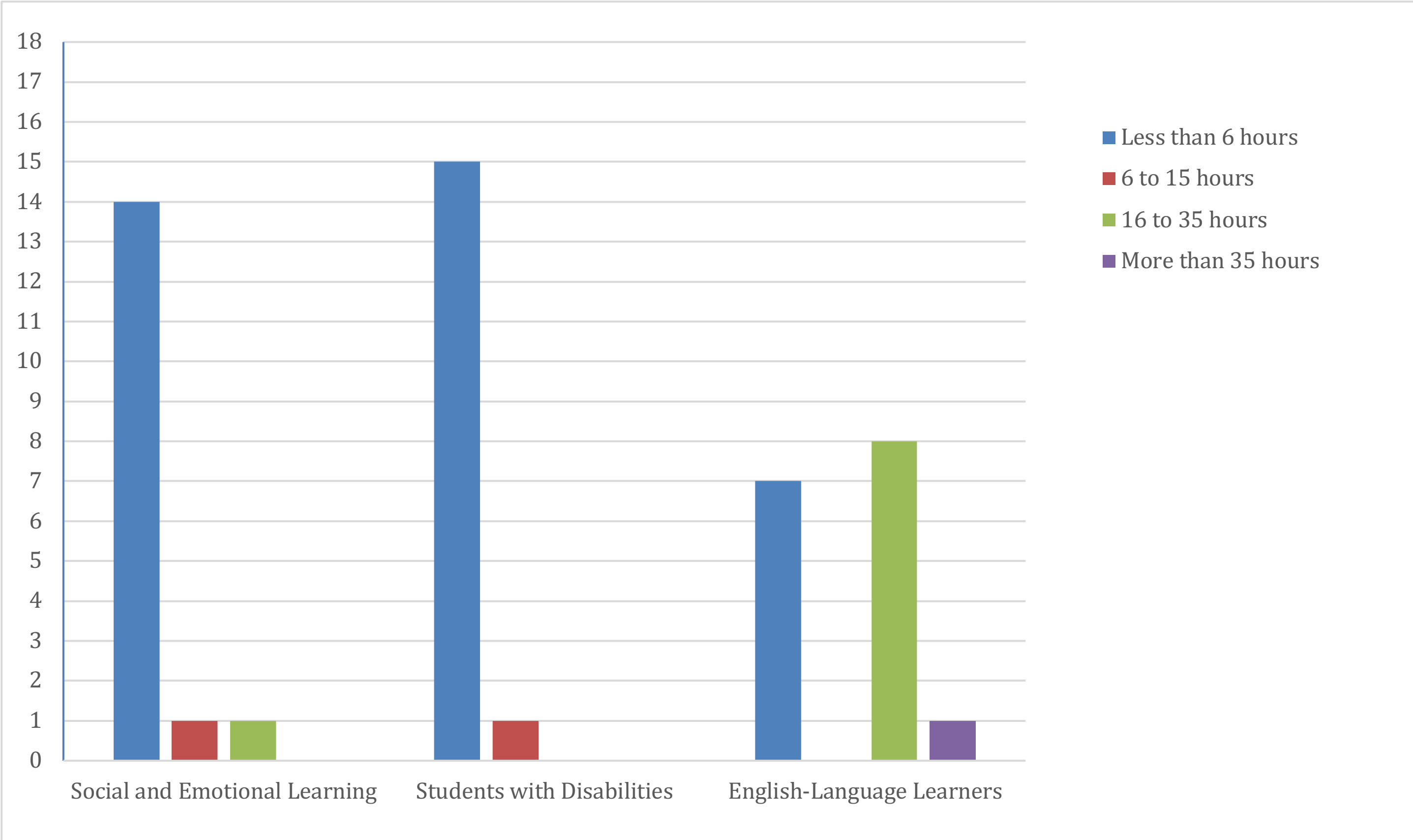


Figure 3. Professional development by topic.

Evaluation Survey

The *STEM Academy for Teachers and Leaders: Academy Evaluation* was used to evaluate the summer academy. The intended purpose of the *STEM Academy for Teachers and Leaders: Academy Evaluation* was to understand participating teachers' beliefs about and experiences with the summer STEM Academy. This instrument was developed by the SMU STEM research team to solicit feedback that could be used to refine and improve the STEM Academy for Teachers and Leaders for future cohorts.

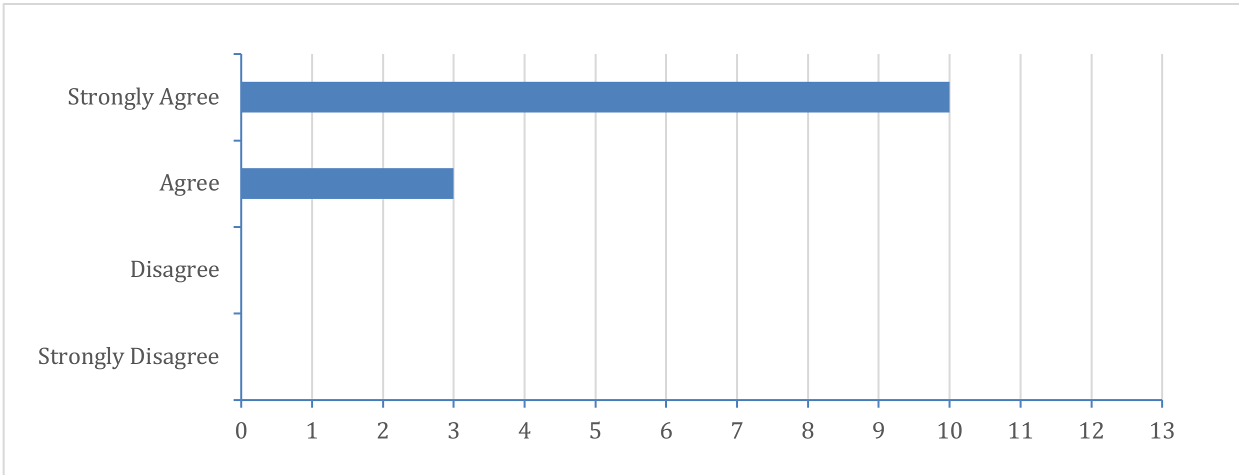
The *STEM Academy for Teachers and Leaders: Academy Evaluation* has 15 overall items (see Appendix C). There are 12 items that ask teachers to determine their level of agreement with a statement. Six of these items contain subtopics within each statement. Respondents select one of the following responses to indicate their level of agreement with each statement: Strongly Disagree, Disagree, Agree, Strongly Agree. Items were developed to gauge teachers' overall impressions of the STEM Academy, including the structure and content of the trainings, as well as impressions of the specific content presentations (e.g., PBL, MBI, GIS) and participation in community resources.

The *STEM Academy for Teachers and Leaders: Academy Evaluation* was administered at the completion of the STEM Academy, after the second portion of online training. The evaluation was administered online through Qualtrics. There was no time limit, and it took teachers an average of 10.08 minutes (*SD* = 9.57) to complete the survey.

Results

Thirteen of the 16 teachers completed the *STEM Academy for Teachers and Leaders: Academy Evaluation.* The results by question are presented in tables and graphs on pages 19-31. A summary of the results can be found on page 32.

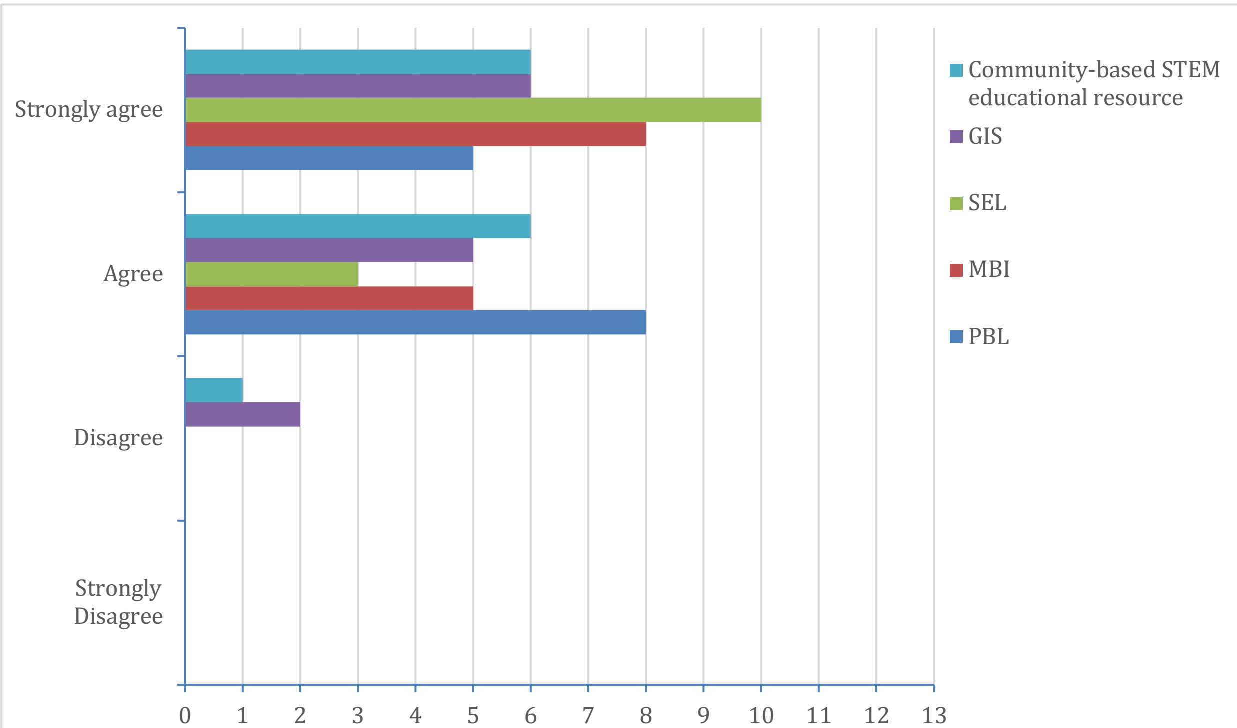
Q1. The STEM Academy was a valuable professional development opportunity.



Response	Count	%
Strongly Agree	10	76.9%
Agree	3	23.1%
Disagree	0	0%
Strongly disagree	0	0%

Q2. The STEM Academy deepened my understanding of:

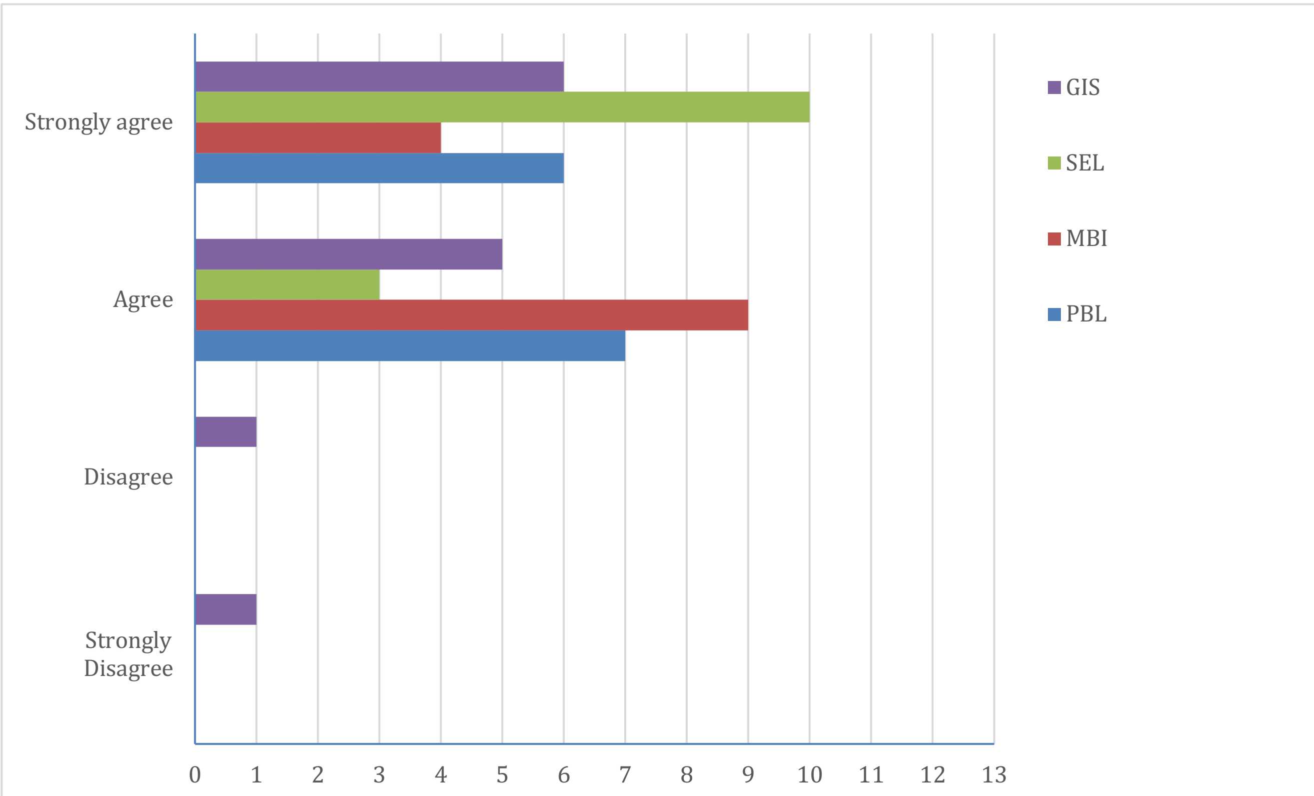
- Project-Based Learning
- Maker-Based Instruction
- Social and Emotional Learning
- Geographic Information Systems
- Community-Based STEM educational resources



Question	Strongly Disagree		Disagree		Agree		Strongly Agree	
	Count	%	Count	%	Count	%	Count	%
Project-Based Learning	0	0%	0	0%	8	62.5%	5	38.5%
Maker-Based Instruction	0	0%	0	0%	5	38.5%	8	62.5%
Social and Emotional Learning	0	0%	0	0%	3	23.1%	10	76.9%
Geographic Information Systems	0	0%	2	15.4%	5	38.5%	6	46.2%
Community-Based STEM educational resources	0	0%	1	7.7%	6	46.2%	6	46.2%

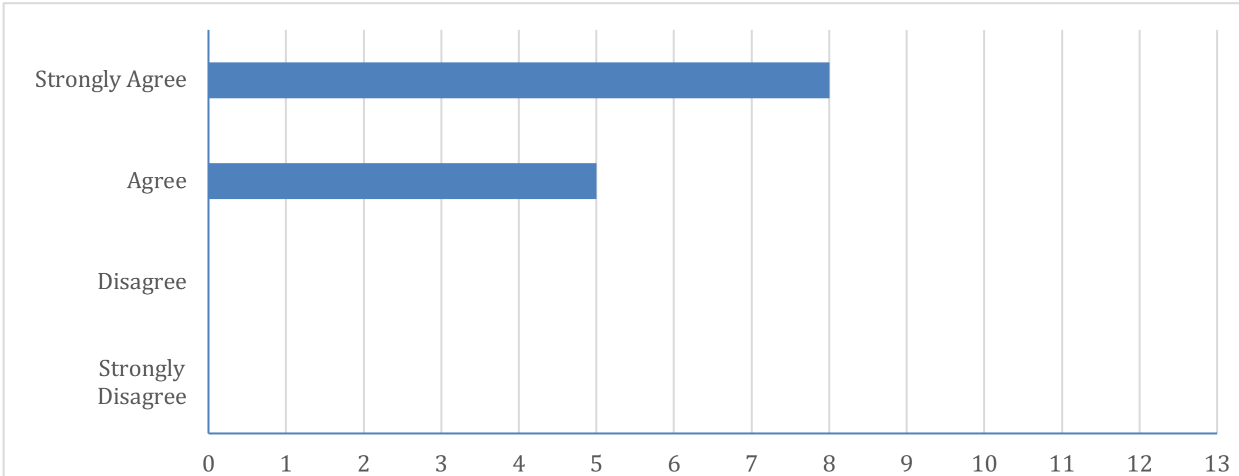
Q3. The STEM Academy provided me with the tools I need to apply in my classroom the principles of:

- Project-Based Learning
- Maker-Based Instruction
- Social and Emotional Learning
- Geographic Information Systems



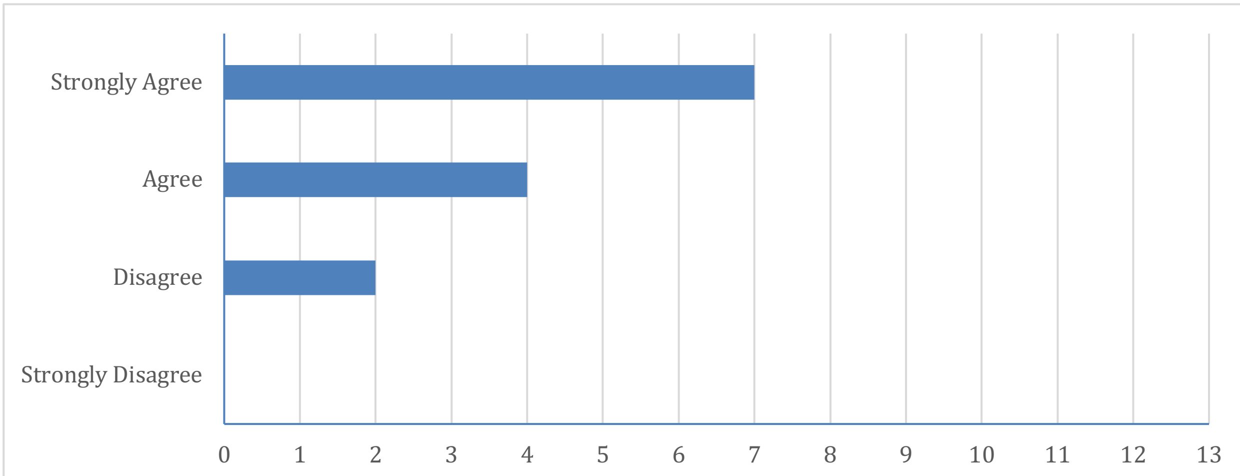
Question	Strongly Disagree		Disagree		Agree		Strongly Agree	
	Count	%	Count	%	Count	%	Count	%
Project-Based Learning	0	0%	0	0%	7	53.8%	6	46.2%
Maker-Based Instruction	0	0%	0	0%	9	69.2%	4	30.8%
Social and Emotional Learning	0	0%	0	0%	3	23.1%	10	76.9%
Geographic Information Systems	1	7.7%	1	7.7%	5	38.5%	6	46.2%

Q4. The knowledge I gained at the STEM Academy will help me improve my science instruction.



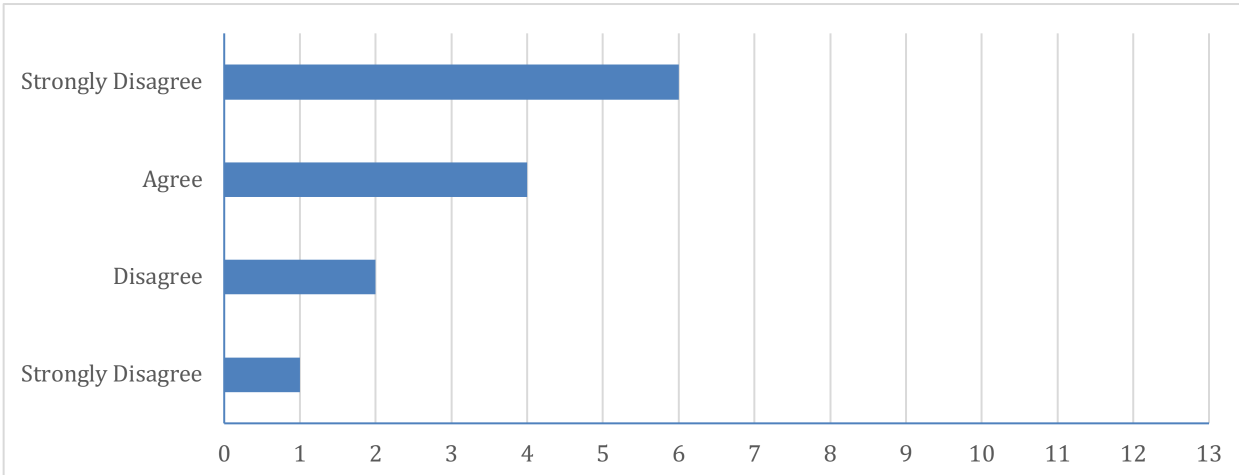
Response	Count	%
Strongly Agree	8	61.5%
Agree	5	38.5%
Disagree	0	0%
Strongly Disagree	0	0%

Q5. The content of the STEM Academy met my expectations.



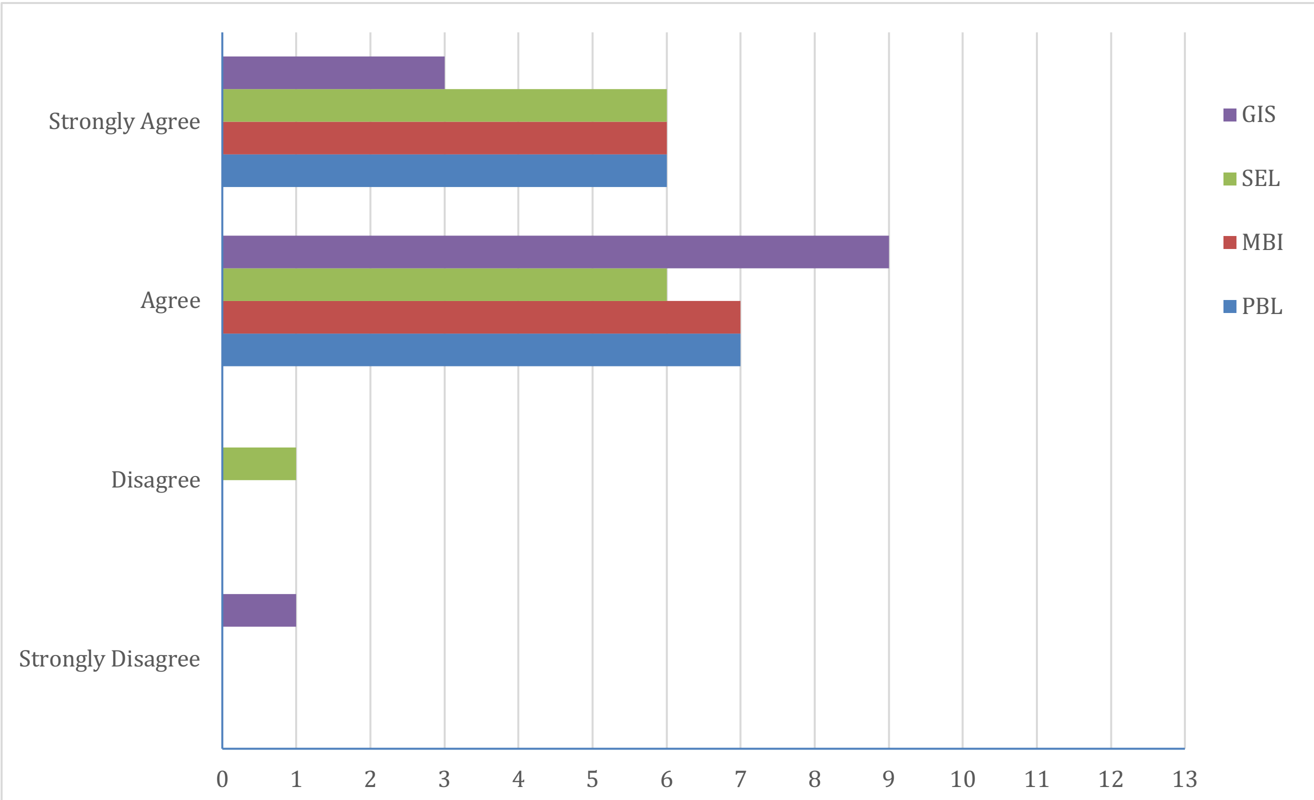
Response	Count	%
Strongly Agree	7	53.9%
Agree	4	30.8%
Disagree	2	15.4%
Strongly Disagree	0	0%

Q6. The structure of the STEM Academy enhanced my understanding of the science content I teach.



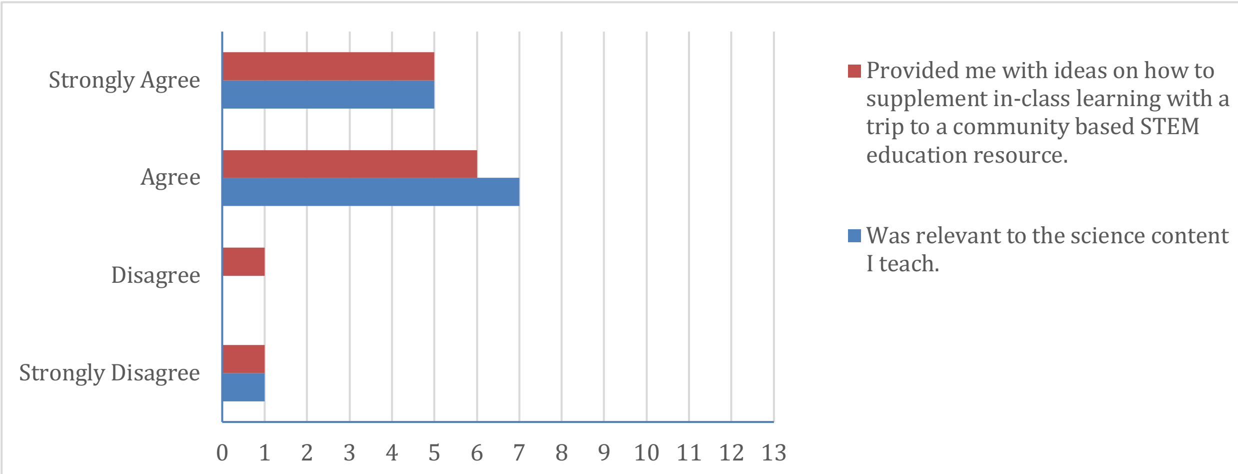
Response	Count	%
Strongly Agree	6	46.2%
Agree	4	30.8%
Disagree	2	15.4%
Strongly Disagree	1	7.7%

Q7. The follow-up coaching and support planned for the school year will help me apply the following concepts in my science instruction:



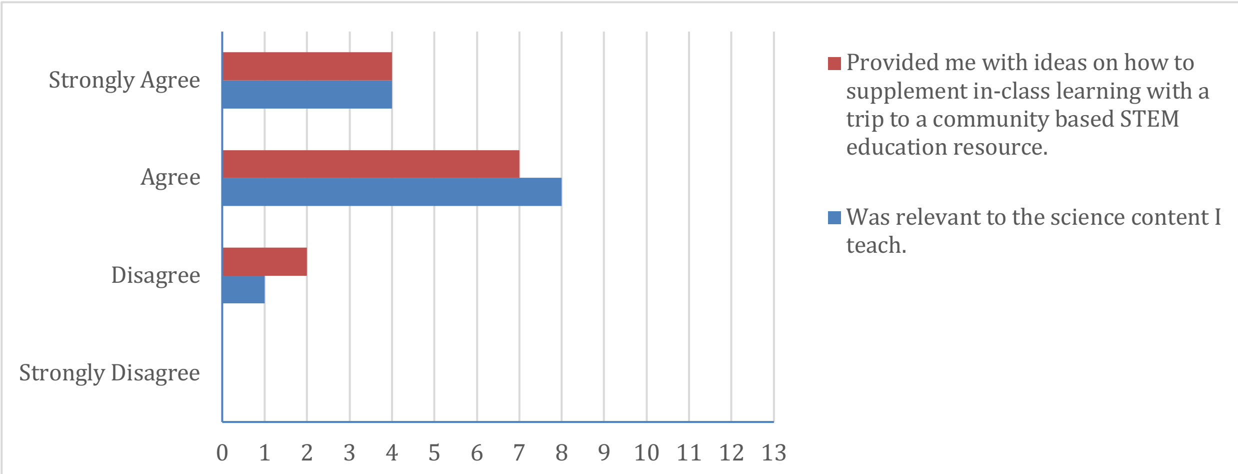
Question	Strongly Disagree		Disagree		Agree		Strongly Agree	
	Count	%	Count	%	Count	%	Count	%
Project-Based Learning	0	0%	0	0%	7	53.8%	6	46.2%
Maker-Based Instruction	0	0%	0	0%	7	53.8%	6	46.2%
Social and Emotional Learning	0	0%	1	7.7%	6	46.2%	6	46.2%
Geographic Information Systems	1	7.7%	0	0%	9	69.2%	3	23.1%

Q8. The field trip to the Dallas Zoo:



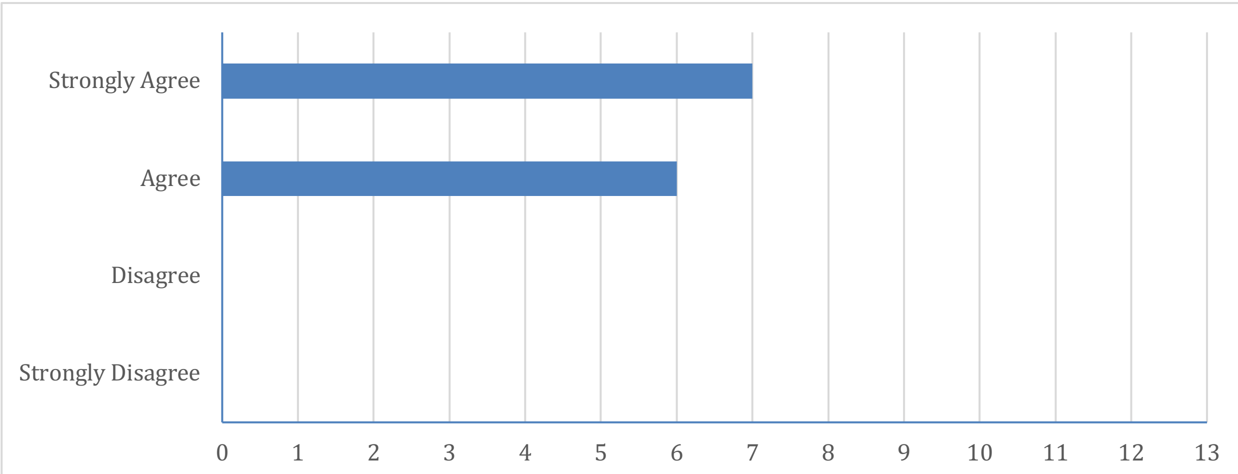
Question	Strongly Disagree		Disagree		Agree		Strongly Agree	
	Count	%	Count	%	Count	%	Count	%
Provided me with ideas on how to supplement in-class learning with a trip to a community based STEM education resource	1	7.7%	1	7.7%	6	46.2%	5	38.5%
Was relevant to the science content I teach	1	7.7%	0	0%	7	53.8%	5	38.5%

Q10. The field trip to the Trinity River Audubon Center:



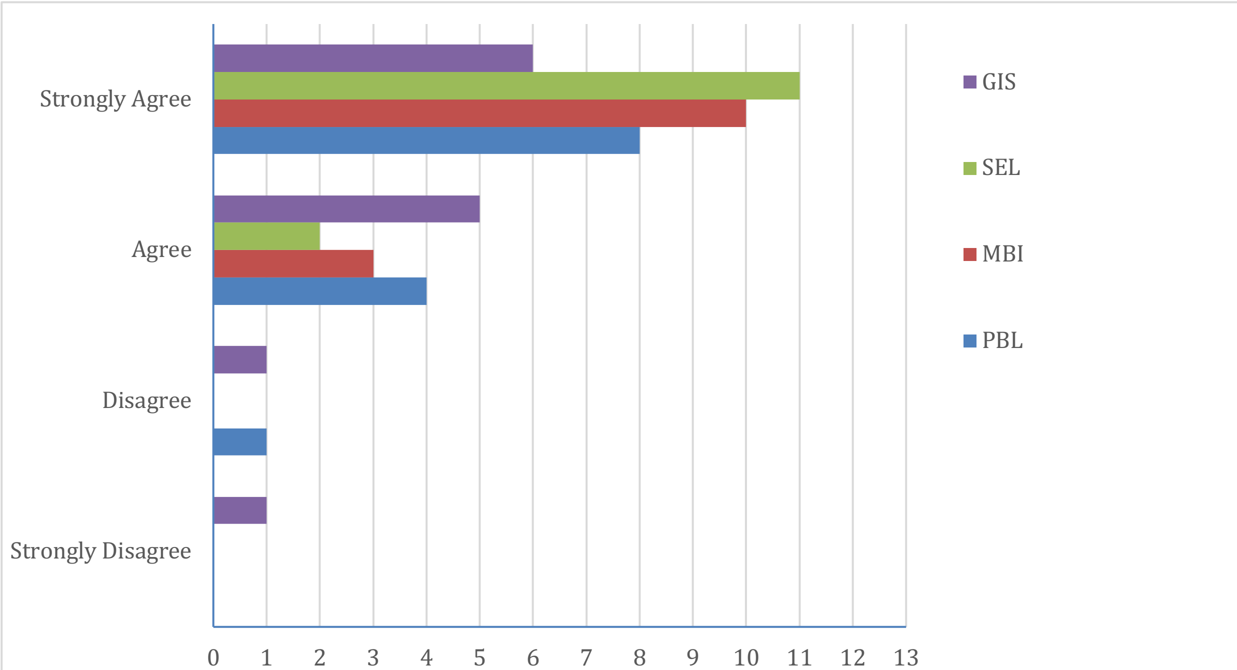
Question	Strongly Disagree		Disagree		Agree		Strongly Agree	
	Count	%	Count	%	Count	%	Count	%
Provided me with ideas on how to supplement in-class learning with a trip to a community based STEM education resource	0	0%	2	15.4%	7	53.8%	4	30.8%
Was relevant to the science content I teach	0	0%	1	7.7%	8	61.5%	4	30.8%

Q11. I will share the knowledge I gained from the STEM Academy experiences with my colleagues.



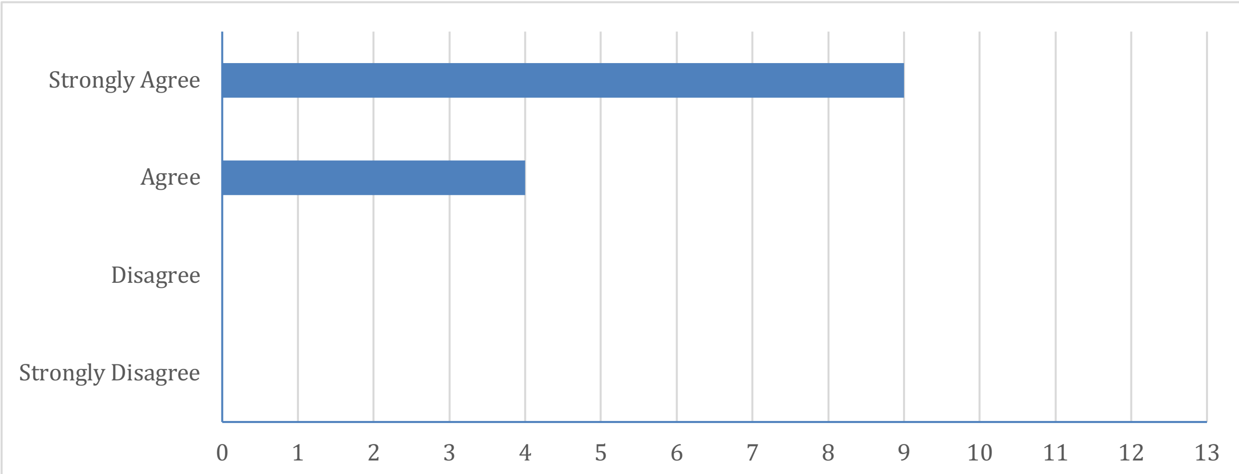
Response	Count	%
Strongly Agree	7	53.9%
Agree	6	46.2%
Disagree	0	0%
Strongly Disagree	0	0%

Q12. Speakers at the STEM Academy workshops delivered high-quality information about:



Question	Strongly Disagree		Disagree		Agree		Strongly Agree	
	Count	%	Count	%	Count	%	Count	%
Project-Based Learning	0	0%	1	7.7%	4	30.8%	8	61.5%
Maker-Based Instruction	0	0%	0	0%	3	23.1%	10	76.9%
Social and Emotional Learning	0	0%	0	0%	2	15.4%	11	84.6%
Geographic Information Systems	1	7.7%	1	7.7%	5	38.5%	6	46.2%

Q13. The STEM Academy was interactive.



Response	Count	%
Strongly Agree	9	69.2%
Agree	4	30.8%
Disagree	0	0%
Strongly Disagree	0	0%

Q14. What areas of the STEM Academy were most useful to you? Please explain.

Open ended responses indicate that teachers felt that instruction on MBI, PBL, and SEL was extremely useful to their practice. MBI was mentioned 7 times, PBL 5 times, and Social-Emotional Learning 7 times. The teachers noted the hands-on nature of instruction, applicability to their own classrooms, and quality presenters as being factors that impacted their response. Additionally, two teachers noted the opportunity to collaborate with others as being useful, while one teacher noted the field trips were most useful.

Q15. Which areas of the STEM Academy need improvement? Please explain.

Overall, most of the suggestions for improvement centered on the visits to the community-based STEM education resources. Five teachers made comments about these trips. These comments indicate that some of the teachers did not believe these trips were accessible to all teachers (e.g., teachers with medical conditions), aligned with grade 8 science content, or feasible to implement with students. Two teachers also suggested that the trips should be moved to Friday and be optional.

Three teachers also offered suggestions about how to improve the GIS instruction, such as linking the content more closely to grade 8 science TEKS and reducing the length of the presentation.

Comments were also provided about how to improve the structure of the STEM Academy. For example, suggestions were made to make the online pre-academy content more interactive, include more time and practice for creating lesson plans, and reduce the amount of stationary learning.

Summary of Results

Every teacher (100%; 13/13) agreed that the STEM Academy was a valuable professional development opportunity and that the knowledge gained at the STEM Academy would help them improve their science teaching, with 77% (10/13) and 62% (8/13) strongly agreeing, respectively. This belief is supported by the fact that all teachers noted that they would be sharing the knowledge gained at the STEM Academy with their colleagues.

Overall, the structure and content of the STEM Academy also met teachers' expectations – 77% (10/13) of teachers agreed that the structure of the STEM Academy enhanced their understanding of the science content they teach. Additionally, 85% (11/13) of teachers agreed that the content of the STEM Academy met their expectations. All teachers agreed that the STEM Academy was interactive, with 69% (9/13) strongly agreeing. Teachers' responses also indicate that that they felt that the speakers at the STEM Academy presented high-quality information. All teachers (100%; 13/13) agreed that the speakers presented high-quality information about MBI and SEL, while 92% (12/13) and 85% (11/13) said the same about PBL and GIS, respectively.

The teachers also noted positive experiences with the two community-based STEM education resources (i.e., Dallas Zoo, Trinity River Audubon Center) visited during the STEM Academy. Eighty-five percent of teachers (11/13) agreed that these visits provided them with ideas on how to supplement in-class learning with a trip to a community-based STEM educational resource, and 92% (12/13) of teachers agreed that the community-based STEM education resource was relevant to the science content they teach.

The results from this survey also indicate that teachers' knowledge increased as a result of the STEM Academy. All teachers (100%; 13/13) said that their knowledge of PBL, MBI, and SEL deepened during the STEM Academy. The majority of teachers also felt their knowledge of community-based STEM educational resources and GIS deepened [92% (12/13) and 85% (11/13), respectively].

The teachers also noted that they felt equipped with the tools needed to apply the principles from the STEM Academy in their classrooms. All teachers (100%; 13/13) either agreed or strongly agreed that they were provided the tools needed to apply PBL, MBI, and SEL principles in their classrooms. The majority of teachers (85%; 11/13) also felt equipped to apply GIS in their classrooms. This is particularly positive since the majority of teacher had very little previous professional development on these topics (see Figure 2 and Figure 3).

While the majority of teachers felt equipped after the STEM Academy, all teachers (100%; 13/13) agreed that the follow-up coaching planned during the school year would help them apply PBL and MBI in their instruction. Ninety-two percent of teachers (12/13) noted the follow-up coaching would assist them in applying GIS content and principles of SEL.

While teachers reported positive experiences at the STEM Academy, teachers' feedback will be used to discuss ways to improve the STEM Academy. Most of the suggestions centered on improving the field experiences at the community-based STEM education resources and improving the structure of the STEM Academy. For example, multiple teachers noted that the field experiences should be chosen and planned so that they are accessible to all teachers, including those with medical conditions or physical difficulties. Additional comments suggested shifting the field experiences to Fridays or making them optional. Comments about the structure of the STEM Academy were also prevalent, including suggestions to make the online modules more interactive and including additional time within the STEM Academy to create lesson plans. All of the feedback from the teachers will be used to discuss and make improvements to the STEM Academy.

In summary, these results indicate that teachers' positive experiences with PBL, MBI, GIS, and SEL deepened their knowledge of the four key areas of the STEM Academy: (1) inquiry-based instruction, (2) scientific process standards, (3) teacher content knowledge, and (4) differentiated support for all learners. Teachers reported that they received high-quality information from engaging presenters in an interactive environment. Teachers concluded the academy with deeper content knowledge, feeling equipped to apply inquiry-based instruction and scientific process standards in their classrooms to support all learners.

Appendix A – Presenter Bios

Multiple experts served as presenters at the STEM Academy for Teachers and Leaders. A brief biographical sketch is included below.

Robyn Hartzell: With over 18 years of experience as an educator, Robyn Hartzell has had the opportunity to serve 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, Hartzell 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. Most recently, she has been serving as an adjunct instructor for SMU in the Teaching and Learning Department where she has had the opportunity to teach a graduate level course on PBL that was created in partnership with Dallas ISD.

Paul Krueger: Paul Krueger, Ph.D., received his B.S. in Mechanical Engineering in 1997 from the University of California at Berkeley. He received his M.S. in Aeronautics in 1998 and his Ph.D. in Aeronautics in 2001, both from the California Institute of Technology (Caltech). In 2002 he joined the Mechanical Engineering Department in the Lyle School of Engineering where he is currently a Professor. He is a recipient of the Rolf D. Buhler Memorial Award in Aeronautics, the Richard Bruce Chapman Memorial Award for distinguished research in Hydrodynamics, the Faculty Early Career Development (CAREER) Award from the National Science Foundation (2004), and the Ford Senior Research Fellowship (2012). His research interests include unsteady hydrodynamics and aerodynamics, vortex dynamics, bio-fluid mechanics, bio-morphic propulsion, fluid-boundary and fluid particle interactions, and fluid processes in additive manufacturing (3D printing).

Katie Krummeck: Katie is the director of the Deason Innovation Gym at the Lyle School of Engineering at SMU. Katie is an educator by training, a maker by trial and error, a learning experience designer and a steadfast believer in the power of empathy to bring compassionate solutions to the messiest of human problems. Before directing the Deason Innovation Gym, Katie was most recently working to bring design thinking to K12 education at the Hasso Plattner Institute for Design (d.school) at Stanford University. At the d.school, Katie also lead the latest rev of the SparkTruck project, a mobile makerspace for kids.

Roger Palmer: Roger is the science chair at Bishop Dunne Catholic School in Dallas, a position he has held for the past 16 years. He also directs operations at the award-winning curriculum design company: GISetc working on k-college technology lessons. Roger has coauthored seven books, 180 science lesson sets, twelve professional research articles, and presented at over 170 conferences. He loves how stories lure their readers to unravel mysteries from information embedded in interactive maps. Hundreds of teachers have joined he and his wife in technological adventures from Hawaii to the Rockies, the great plains to the great lakes, and Australia to Abu Dhabi. Roger has collaborated on projects with National Geographic, NASA, the National Research Council, the National Audubon Society, SpaceX engineering, ESRI, Pasco Scientific, Frey Scientific, Chabot Observatory, and many other outdoor educational centers.

Dara Rossi: Dara Rossi, Ph.D., joined the faculty of Simmons School of Education & Human Development at Southern Methodist University in 2010. She earned her Ph.D. from the University of North Texas with a major in Curriculum and Instruction and a minor in Educational Administration. Additionally, she holds a Master’s degree in Science Education from the University of Texas at Dallas. Dr. Rossi is an experienced educator with a strong science background, including K-12 curriculum development and administration. Prior to coming to SMU, she taught undergraduate and graduate courses at the University of North Texas in secondary education. Her primary research interests concern the interconnectivity of STEM and teacher development.

Rob Rouse: Rob Rouse, Ph.D., joined the Annette Caldwell Simmons School of Education & Human Development after completing his Ph.D. in Mathematics and Science Education at Vanderbilt University’s Peabody College. At Vanderbilt Dr. Rouse 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, Dr. Rouse 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. Dr. Rouse’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.

Appendix B – Reference List

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Appendix C – Survey Instrument

STEM Academy for Teachers and Leaders: Academy Evaluation

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 Geographic information systems (GIS) 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 o Geographic information systems (GIS)				
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: o Project-based learning o Maker-based instruction o Social and emotional learning o Geographic information systems (GIS)				
8. The field trip to the Dallas Zoo was: o was relevant to the science content I teach. o 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 the Trinity River Audubon Center: o was relevant to the science content I teach. o provided me with ideas on how to supplement in-class learning with a trip to a community-based STEM education resource.				
10. I will share the knowledge I gained from the STEM Academy experiences with my colleagues.				
11. Speakers at the STEM Academy workshops delivered high-quality information about: o Project-based learning o Maker-based instruction o Social and emotional learning o Geographic information systems (GIS)				
12. The STEM Academy was interactive.				

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

14. Which areas of the STEM Academy need improvement?

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