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RESEARCH IN MATHEMATICS EDUCATION

STEM Academy for Science Teachers and Leaders: 2019 Teacher Academy 3 Evaluation

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STEM Academy for Science Teachers and Leaders: 2019 Teacher Academy 3 Evaluation

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Executive Summary

Many studies over the past decade have indicated that relatively low numbers of students in the United States pursue STEM education degrees, which is causing fewer individuals to be prepared to enter STEM career fields (DeJarnette, 2012). This should be concerning to educators and society because “STEM education should provide an enhanced and more equitable range of career options”, which are essential to continued economic and technological advancement (Lynch et al., 2018, p. 713). The STEM Academy for Science Teachers and Leaders is an intervention designed to support middle school science teachers and leaders in Dallas Independent School District (ISD) in a multitude of ways. Ultimately the objective is to increase student interest in STEM fields, thereby improving the likelihood that more students will persist along a STEM career trajectory.

This report focuses on the experiences and perceptions of the first cohort of teachers participating in the third of three STEM summer academy courses. This summer academy course is comprised of two separate courses in the Southern Methodist University (SMU) course catalog. The first is titled The Science of Learning and STEM Education and the second is titled Teacher Leadership through Coaching. These courses and other online supplemental components will hereafter be referred to as Academy 3 in this report. The content of Academy 3 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) active-learning which includes inquiry-based STEM instructional strategies such as project-based learning (PBL) and maker-based instruction (MBI), (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 3 during summer 2019. These teachers were part of the first cohort of participating teachers who attended Academy 1 during the summer 2017, attended Academy 2 during the summer 2018, and received coaching during the 2017-18 and 2018-19 academic years. The structure and content of Academy 3 built on teachers’ experience during the first two years of participation in the program, including the previous Summer Academies in 2017 and 2018. Academy 3 focused on how the design of learning environments and the integration of STEM across all lessons can improve student learning in this field. Additionally, Academy 3 included several coach development aspects such as formulating action plans, building self-awareness, and clarifying individual and departmental goals as a means of improving teacher confidence and competence in the science classroom. The accompanying pedagogical strategies were intended to help teachers continue to develop skills associated with the four main pillars indicated above.

In addition to summarizing the experiences and perceptions of cohort 1 teachers (n= 10) regarding Academy 3, 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 majority of the participating teachers responded positively to all of the survey questions. Specifically, 100% of the teachers agreed or strongly agreed that Academy 3 will help them

improve both their own and others' science instruction. Additionally, 100% agreed or strongly agreed that Academy 3 was interactive, built on previous years' content, and met their overall expectations. The majority of teachers (over 75%) also agreed or strongly agreed that Academy 3 deepened their understanding of 12 different STEM instruction and active learning concepts, provided tools that could be applied in the classroom, and exposed them to speakers with high-quality information. Finally, the majority of teachers (over 75% for each component) indicated that they agreed or strongly agreed that the coaching planned for the upcoming academic year would help them apply the 12 STEM instruction and active learning concepts in their classroom.

On the open-ended response questions the teachers were asked about which aspects of Academy 3 were most helpful and which aspects of Academy 3 could be improved upon. Seven out of eight (88%) respondents indicated that the coaching training was a valuable component. Four out of eight (50%) of respondents also mentioned STEM integration as being helpful when planning to implement Academy 3 strategies in their classroom during the upcoming year. Overall the teachers responded positively, with 100% mentioning that they gleaned valuable content from their experience. Only two out of eight (25%) teachers mentioned areas that could be improved upon, specifically better connections to the Texas Essential Knowledge and Skills (TEKS) and more planning time for lessons that can be utilized in the classroom without additional modification.

Three recommendations for improving Academy 3 in the future are suggested, based on the results and analysis within this report. First, the core structure and activities within Academy 3, especially the emphasis on teacher leadership and coaching, should continue with minor, if any, adjustments in future years. This recommendation is based on teachers' overwhelmingly positive perceptions of Academy 3. Second, Academy 3 facilitators should make explicit connections to both the science content and the process standards in order to specifically exemplify the connection for participating teachers. Finally, future presentations of Academy 3 should attempt to minimize the time that teachers work at home after face-to-face sessions.

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STEM Academy for Science Teachers and Leaders: 2019 Teacher Academy 3 Evaluation

Background

During the first decade of the 21st century, the number of STEM related jobs grew at three times the rate of non-STEM jobs (Smithsonian, 2018). Both the American and global economies are requiring more individuals with STEM related degrees to fill professional positions in an increasingly high-tech job market (DeJarnette, 2012).Although the United States has experienced growth in this field, it has not seen the same growth in qualified STEM workers as its global competitors in Europe and Asia (National Science Board, 2010).

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 Independent School District (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) active-learning which includes inquiry-based STEM instructional strategies such as project based learning (PBL) and maker-based instruction (MBI), (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; Adams, et al., 2018; Adams, Hatfield, Cox, & Ketterlin-Geller, 2018; Pierce, Adams, Rhone, Hatfield, & Ketterlin-Geller, 2019). Through these conversations, desired outcomes were determined that would help initiate and refine the goals of this 4-year project. 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

There are two main components of the STEM Academy for Science Teachers and Leaders (STEM Academy hereafter). The first is an intensive 90-hour professional development academy each summer, and the second is onsite coaching and professional learning community (PLC) facilitation that occurs during the academic year at the ISD campus level. 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; Adams, et al., 2018; Adams, Hatfield, Cox, & Ketterlin-Geller, 2018; Pierce, Adams, Rhone, Hatfield, & Ketterlin-Geller, 2019).

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

During their third summer of participation, cohort 1 teachers experienced two separate courses from the SMU course catalog. The first is titled The Science of Learning and STEM Education and the second is titled Teacher Leadership Through Coaching. These courses and other online supplemental components administered by the STEM Academy facilitators will hereafter be referred to as Academy 3. Academy 3 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.

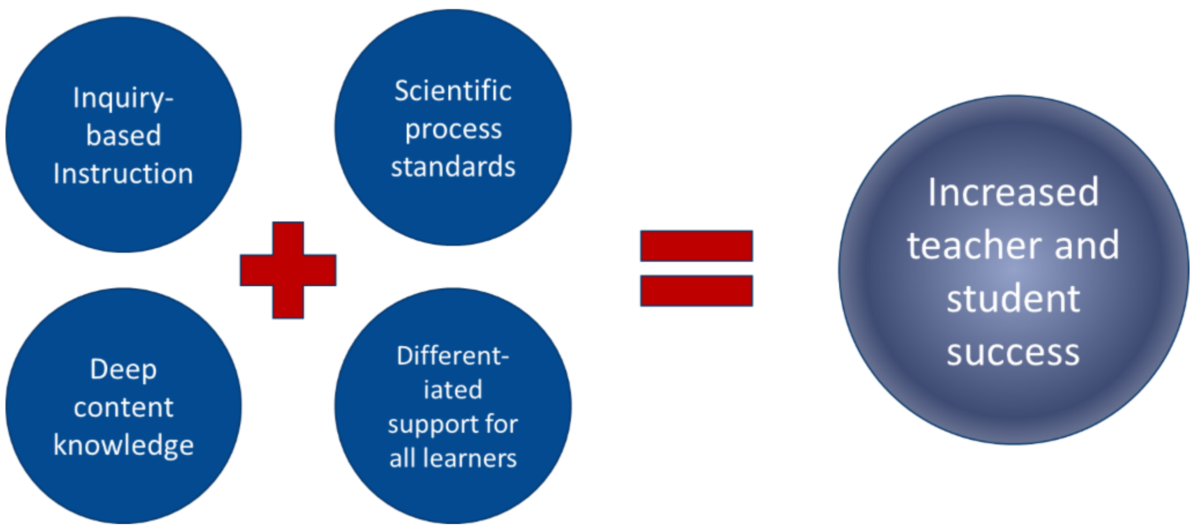

Figure 1. Foundational Pillars of the STEM Academy

As shown in Figure 1, the main outcome of the STEM Academy is student-centered (i.e., increased student success). Academy 3 focused on the development of participating teachers as leaders in their departments as a means of achieving this goal. Active learning and inquiry-based instruction in the science classroom lead to a better conceptual understanding by students according to studies conducted between 1984 and 2002 (Minner, Levy, & Century, 2010). Furthermore, a 2017 study identified sustained professional development in inquiry-based instructional strategies for teachers as having a positive trend on student growth in science mastery and a narrowed achievement gap within the scientific fields for students (Marshall, Smart, & Alston, 2017; Geier, Blumenfeld, Marx, Krajcik, Fishman, Soloway, & Clay-Chamber, 2008). Integrated STEM high schools examined in 2018 specifically supported teacher development by providing “extensive, regular, and embedded professional development that was thoughtfully designed (often by teachers) and tailored to the goals of the school” (Lynch et al., 2018, p. 734). An understanding of the scientific process standards and deep content knowledge is required for effective implementation of inquiry-based and active learning instruction (NRC, 2000), so utilization of the Texas Essential Knowledge and Skills (TEKS) was embedded in several aspects of lesson design during Academy 3. Finally, within the STEM Academy, differentiated support for all learners emphasized attending to students' social and emotional learning (SEL). It has been suggested that teachers who have higher social and emotional competence have better teacher-student relationships and better management of their classrooms through differentiated support structures, ultimately leading to better student learning (Jennings & Greenburg, 2009).

Academy 3 content built on these foundational pillars, which were cultivated during Academies 1 and 2 (see Perry et al., 2017 and Pierce et al., 2019 for more detail). Academy 3 continued to develop teachers' understanding and implementation of maker-based instruction (MBI) and project-based learning (PBL), through use of Integrated STEM Education (iSTEM), protocol use during Professional Learning Community (PLC) meetings, and peer coaching strategy development. Continuing cohort 1 middle school teachers (n=10) from six Dallas ISD schools participated in Academy 3 during summer 2019.

Purpose of this Report

The purpose of this report is to: (a) provide an overview of the components and the goals of Academy 3, and (b) summarize cohort 1 teachers' perceptions of the Academy 3 coursework, which occurred during their third year of participation in the STEM Academy for Science Teachers and Leaders.

This report details an evaluation of the summer Academy 3 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 3 and their experiences. This report includes information about the content and structure of Academy 3, demographic details about the participating teachers, and details the results from an evaluation survey completed by the teachers at the end of Academy 3.

The results of this report are designed to inform future improvements to the design and structure of Academy 3.

Evaluation Question

In addition to describing the content, structure, and activities included in Academy 3, this report focuses on the following evaluation question:

- What are teachers' perceptions of the STEM Academy 3 based on the academy evaluation survey?

Content and Structure of Academy 3

The SMU project team designed the content and structure of the Academy 3 to meet the goals and objectives of the project and align with the needs and constraints of middle school science teachers. As with previous academies, the SMU project team conducted a portion of Academy 3 online and a portion face-to-face, to meet the practical constraints of the science teachers. Participating teachers received 90 hours of professional development: 70 hours of face-to-face coursework on the SMU campus during two weeks in June 2019, and 20 hours of online coursework. The online coursework was divided into two parts, 10 hours before the face-to-face academy which was associated with the Science of Learning course offered at SMU and 10 hours after the face-to-face academy which was associated with the Teacher Leadership Through Coaching course. Academy 3 was structured similarly to Academies 1 and 2, which the teachers all participated in during the previous two summers.

In keeping with the goals of the project, Academy 3 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 active learning 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, such as the 5E and question formulation technique models, along with suggested modifications based on what the teachers reported had occurred in their classrooms during the previous year. During Academy 3 all of these essential concepts were revisited, and additional components of teacher leadership and PLC structure and function were added. In the sections that follow, these instructional approaches are described in detail.

Active Learning

A recurring theme throughout all three years of the STEM Academy has been active learning through inquiry-based pedagogical strategies. Over the first two years, cohort 1 teachers were exposed to a variety of active learning options (e.g. MBI, PBL, 5E), and during Academy 3 the focus was broadened to active learning in general. During the course of the lessons, labs, activities, and group collaborations, teachers were asked to synthesize all of the information about active learning strategies that they had previously received and allow this to influence the plans they were making for their classrooms for the upcoming academic year.

The two major strategies discussed in previous years were MBI and PBL. 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 because students develop personalized solutions to a problem and the outcomes are variable, not pre-determined. 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. For both of these strategies, differentiation occurs at the problem development phase, and a single classroom may have multiple essential questions directing a variety of projects.

During Academy 2 the 5E model was emphasized. 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.

Academy 3 continued the prominence of active learning by focusing on Integrated STEM Education (iSTEM) and learning environment design. As the professional world becomes increasingly multidisciplinary (e.g. biomedical engineering), education should adapt the delivery methods for the STEM subjects of science, technology, engineering, and mathematics. iSTEM is an approach that advocates for the integration of these different disciplines, which are frequently distinct from each other in schools. Supporters "highlight connections within, between, and among the STEM subjects" (Honey, Pearson, & Schweingruber, 2014, p. 19). This integrated use of traditionally separate content areas resembles reality as individuals must utilize information and concepts from a variety of subjects and sources in order to navigate the world around them.

Professional Learning Communities

The use of PLCs to focus on learning, collaborative work, and holding teachers and departments accountable for student results is utilized by many school districts, including Dallas ISD. PLCs were included in Academy 3, because as cohort 1 teachers developed to be leaders on their campuses, they would need to understand the major principles of PLC functionality. Although PLCs can be comprised of many different groupings of educators, the majority of PLCs that cohort 1 teachers had participated in are intradepartmental and usually include teachers from several grade levels.

PLCs are traditionally structured around three big ideas (DuFour, 2004). First, ensuring that students learn, the emphasis is on the need for student learning as opposed to teacher teaching. The second big idea is developing a culture of collaboration. There is "compelling evidence indicating that working collaboratively represents best practice" and identifying protected time to work in a PLC allows teachers the opportunity to do just this (DuFour, 2004, p.9). Third, it is essential that PLCs focus on results. Successful PLCs continuously identify the level of current student achievement, describe problems inhibiting growth, develop solutions to be implemented, and then evaluate the impact based on evidence.

Increased teacher and student success was the main purpose of the STEM Academy, therefore providing the participating teachers with the tools necessary to understand and evaluate student results helped achieve this goal.

Teacher Leadership

Throughout Academy 3, teachers in cohort 1 were developed to take on leadership roles on their campuses. Many of the participating teachers already have leadership responsibilities such as instructional coach, PLC leader, or department head, and all of the teachers benefited from further development of coaching and leadership strategies. The majority of this content came from one of the face-to-face academy courses, titled Teacher Leadership Through Coaching. Additionally, the teachers received training on PLC facilitation, protocol use, and norm setting.

Social and Emotional Learning

SEL was first formally introduced during Academy 1, and although direct training on the five social and emotional competency areas (i.e. self-awareness, self-management, social awareness, relationship skills, and responsible decision making) did not take place during Academy 3, SEL components were incorporated throughout. Self-awareness and 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. Social awareness and relationship skills were essential to completing Academy 3 due to the collaborative nature of many of the professional development activities and course assignments, and 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 strategy being formally emphasized and studied.

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 visits to the Meadows Museum on the SMU campus and Spark!. Additional information on the topics from the STEM Academy and the community-based educational resources is included below.

Content Knowledge and Process Standards

Academy 3 was comprised of the main components listed above, but it is understood that effective implementation of active learning through inquiry strategies requires an in depth understanding of the scientific process standards and deep instructor content knowledge. When active learning 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 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 active learning instructional strategies throughout Academy 3. Although specific emphasis was not placed on content knowledge or the process standards during every assignment or exercise, their underlying inclusion was omnipresent.

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 employed their content knowledge and the process standards to teach high-priority TEKS. The expectation of Academy 3 is that teachers in cohort 1 will utilize the coaching and leadership strategies presented to facilitate widespread implementation of the active learning strategies that they have become familiar with on their separate campuses.

Activities within Academy 3

This section outlines the activities conducted for each of the primary content areas. Academy 3 activities were designed to strengthen teachers' understanding of STEM education as defined by the four foundational pillars. Academy 3 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 3, the participating teachers completed 10 hours of online coursework which was associated with the Science of Learning course. These modules focused on three strategies including iSTEM, Experts vs. Novices, and PLCs, with the goal of having teachers further develop their approach to active learning in their classroom and leadership opportunities at their school. The following section describes the main emphases of the online modules that teachers completed prior to attending the face-to-face Academy 3 sessions.

Integrated STEM Education

During the online coursework, participating teachers read information about integrated STEM, specifically in the K-12 classroom. Two chapter from *STEM integration in K-12 education: Status, prospects, and an agenda for research* (2014) served to introduce the definitions of each component of STEM as well as the connections between these components. Additionally, the teachers read about a variety of studies and initiatives over the past decade that have worked towards true STEM integration. Emphasis was given to areas in need of future research and a prediction about the scope that a STEM integration policy would need to have.

The teachers read about how standards can be integrated from different disciplines (e.g. math, engineering) and they considered the cross connections between goals in each of these traditionally different departments. Next, the chapters covered assessments, both requirements and the pressures that teachers and students can experience from mandated assessments. Finally, the chapters concluded with information about educator expectations and self-efficacy.

The participating teachers completed the following reflection questions independently:

- In your own words, summarize the current argument for expanding and improving K-12 STEM education in the United States.
- What are your thoughts on the way STEM subjects have traditionally been taught (i.e., as discrete subject areas)?
- Select one of the STEM subjects described in chapter one and briefly characterize it in your own words. Is it popular in K-12 schools? What are some important concepts within the subject? How do people generally think of the subject?

- What do you make of the current landscape of STEM standards (chapter 5)? In your opinion, do these standards help or hinder integrated STEM efforts?

- The following is a quote from pages 115-116: "Preparing effective, confident teachers in single academic subjects is no easy task, and the task is likely to be more challenging for educators capable of guiding students in integrated STEM education." What are your reactions to this quote?

Next, the teachers watched a video about STEM and how often the "T" for technology is underrepresented in K-12 curriculum. The video also looked at how each of the subjects are typically taught in isolation and gave several examples of how these subjects are actually integrated in the real world and job market. The teachers then answered the following reflection questions and prepared to share their thoughts during the face-to-face portion of the academy. Reflection questions:

- What are the benefits and limitations of integrated STEM education?

- What are the implications of integrated STEM education for how schools are organized?

- How can teachers be prepared to teach in integrated ways?

- How can we find out what kids are learning and able to apply based on these integrated STEM experiences?

To conclude this section, the teachers worked in groups to research assigned STEM process standards and TEKS. They were asked first to read and evaluate the standards of the disciplines other than science, and then to determine how the standards are organized and what bridges to integrated STEM were apparent.

Experts vs. Novices

To begin this section the teachers began by reading two book chapters about how people learn. The first was *The New Science of Learning* by R. K. Sawyer in 2006 and the second was *How People Learn* (HPL) released by the National Research Council in 2000. Each chapter referenced studies about how important deeper conceptual understanding, creating learning environments, building on prior knowledge, and reflection are to the learning process. The chapters also asked the teachers to consider the difference between teaching and learning, the goals of education, and the nature of expert knowledge. Differences in memory, problem grouping, and problem solving can emerge depending on the amount of expertise the student has in the subject area, thereby causing the results a teacher receives to be different based on whether the student is an expert or a novice on the topic. In order to develop students into successful problem solvers, they must be trained to pull only the relevant information into their working memory and consider problems with the correct context.

After reading the two chapters, the teachers were asked to reflect on the content, guided by the following questions:

- In your own words, summarize the major differences between the traditional view of schooling (i.e., instructionism) and the new view of schooling (i.e., the learning sciences). What theories and actions underlie each of these views on schooling?

- According to Sawyer, what is an “education entrepreneur?” Is it practical for K-12 STEM teachers to become education entrepreneurs? Why or why not? What are some challenges that stand in the way of STEM educators becoming education entrepreneurs?

- Why do we care about the differences between experts and novices? In other words, why is this a topic worth studying?

- Select one of the examples covered in the *HPL* reading (e.g., physics, history, teaching) and explain several of the key differences between experts and novices in that field.

- On page 42 of *HPL*, the authors use the phrase “a mile wide and an inch deep.” What does this phrase mean to you? How does it relate to expertise?

The teachers next watched three videos of experts and novices playing the game Angry Birds, singing a Beatles song, and talking about dinosaurs. They were asked to reflect using the following questions:

- What are your reactions to this video?

- Who was the expert?

- Who was the novice?

- How did the expert’s technique differ from the novice’s technique?

The teachers then gave feedback on their peer’s reflections and discussed commonalities that were present across all of the experts. To conclude this section of the pre-online academy, the teachers shifted their focus back to STEM. They considered who a STEM expert would be, what characteristics a STEM novice would have, and developed a plan for conducting two interviews, one with an expert and one with a novice. This led to preparation for an assignment due during the face-to-face academy with the goal of examining further how STEM experts and novices think differently about a subject or task.

Professional Learning Communities

The purpose of including the PLC sessions in the pre-online academy was to develop a shared understanding amongst cohort 1 teachers of what a PLC is and what value it can offer to supporting teacher and student development. To begin the section on PLCs the teachers were given a few guiding questions to keep in mind as they read the assigned articles about PLCs.

- What are behaviors that ‘drive’ and ‘prevent’ productive PLCs?

- How does a professional learning community support the idea of professional learning as opposed to professional development?

Next, the teachers watched a video clip that exemplified what a PLC should not look like. This was followed by an article that outlined what a PLC should resemble, and the teachers were asked to consider the difference in the two presentations. The article about a functional PLC was structured around three big ideas which include ensuring that students learn, developing a culture of collaboration, and focusing on results. The article describes why each of these components are essential for a PLC to be productive.

The last article examined how collaborative practice in professional development leads to more learning by participants than what typically occurs during traditional professional development. Different aspects of PLCs are discussed which could be incorporated into any adult development program to improve both teaching and learning.

The pre-online content concluded by having the cohort 1 teachers read an article about a teacher who created short, in the moment, video clips of her classroom in order to receive feedback from her PLC. This article is relevant because it offers a strategy with which participating teachers could discuss their specific content or process standard connection as they relate to the actual student and teacher behaviors happening in the classroom.

Teachers were reminded to keep their reflections of these resources until the PLC portion of the face-to-face academy, during which time further discussion would take place.

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 three main emphases of the face-to-face Academy 3 content and activities. Two courses, The Science of Learning in STEM Education and Teacher Leadership Through Coaching, offered through SMU comprised significant portions of the curriculum. The third complimentary and integrated component utilized the skills from these two courses to train cohort 1 teachers to facilitate productive PLC meetings. The following sections describe the main topics and activities that occurred during the face-to-face Academy sessions.

To begin the face-to-face academy the teachers of cohort 1 were enrolled in the first course offered in the STEM Specialization program offered by SMU (not specifically designed for the Academies). As of the summer 2019, 9 of the 10 participating teachers had matriculated into this graduate program, and participation in this course helped them advance both their personal and professional goals.

Each morning of the face-to-face academy Dr. Dara Rossi (please see Appendix A for a full presenter biography) led cohort 1 through The Science of Learning and STEM. In the afternoon of each day Dr. Gail Hartin (please see Appendix A for a full presenter biography) delivered the course Teacher Leadership Through Coaching.

The Science of Learning in STEM Education

The material for this course began during the pre-online academy, and many of the reading assignments and reflection activities that the participating teachers completed were essential to preparing them for the face-to-face components of the course. After completing introductions and reviewing the course syllabus, the teachers began to unpack the term STEM. They watched a video clip about why people should be concerned about STEM and then worked on a STEM activity.

The teachers built geopanes, which are two- and three-dimensional structures that are then dipped into a soapy water mixture. The teachers were asked to follow an instruction handout, make predictions about the final products, and then record their results specifically focusing on what they found interesting and unexpected. Next, the teachers were asked to make a connection to STEM education. They were asked about what topics this activity could be used to teach, and discussed topics in math, science, engineering, and technology that could benefit from the use of geopanes. Teachers considered how they could connect their own content and process standards to other subject areas with the use of manipulative objects produced by students.

During the next session the teachers were given the opportunity to tinker with several different technology items, since during the discussion about the geopanes, the teachers decided that they did not easily lend themselves to incorporating the “T” in STEM. The different technologies presented in this course were:

- Makey Makey – an invention kit for everyone
- Sphero – a programmable robot
- LilyPad – sewable electronics
- Raspberry Pi – free online courses about computing and digital making

Many of these technology options are content agnostic, and the teachers were asked to consider how they could be used to enhance science and STEM classroom instruction.

The teachers then examined how the use of models in math and science could improve learning outcomes for students. The following reflection questions were discussed in order to set the stage for the next building activity.

- What experiences did you have with building models as a K-12 student? What did you take away from these experiences? Do you use models in your classroom? If so, how?
- In your own words, explain the relationship between models, model-based reasoning, and student learning in science and math?
- In your own words, describe how modeling helps with the “teacher agenda?” In other words, how are models useful tools for teachers?
- Beginning on page 41, Lehrer and Schauble outline four different types of models: physical models, representational models, syntactic models, and hypothetical-deductive models. Pick one of these types of models and explain it in your own words.

- Using the ruler as an example, unpack what Lehrer and Schauble mean when they say that, “Because models condense a history of cognitive work into a relatively compact inscription, diagram, or formula, they can render invisible the history of cognitive work that created them.”

They then prepared to build a biomechanical elbow by dividing into groups, examining their own working elbows, and then building a model elbow with provided materials. During the process they documented their progress and shared with the rest of the cohort how their elbow model worked and why they made specific selections and choices. Next, the teachers investigated the biomechanics of elbows. They used an elbow model and string connected to different point to determine how to best construct a functional elbow joint. Data were collected during this entire process and the final results were shared and discussed as a group at the end of the session.

The next day different components of engineering and design challenges (EDC) were covered. The teachers read a report which suggested that EDCs can foster more equitable science education for girls. The main elements that must be present in successful EDCs include clear goals, tests against nature, prototype design, multiple iterations, large dynamic range, and the employment of purposeful record keeping.

The teachers then participated in an EDC to design and build a sound amplification device for a smartphone. After their amplification devices were complete, the teachers considered how they could connect this activity to STEM content. They were provided with the standards documents for science, technology, engineering, and math, and familiarized themselves with the topics included in each discipline while determining which aligned with the smartphone amplification system challenge.

This session concluded with discussion about grading model building and design challenges, and the specific challenges that may arise when assessing a variety of students on differentiated projects. It was recommended that the teachers become comfortable with using a rubric, and the following categories were suggested as being appropriate for assessment:

- Performance
- Record keeping
- Work ethic
- Testing and data collection
- Presentation
- Reflection

These categories allow for groups of students who may be unsuccessful in their design challenge to still be successful in their learning and class evaluation.

The teachers read and discussed a different design challenge about sending a Pringle chip through the mail without letting it get broken, and then transitioned into the Expert vs. Novice content that they had begun during the pre-online academy.

Each pair of teachers finished conducting their interviews, if necessary, and writing up their results. They presented to the cohort and described challenges and interesting observations that they had during the course of the assignment.

Next, the teachers read two book chapters about designing learning environments and answered the following reflection questions.

- In your own words, summarize why we (as teachers or as people who are interested in teaching) should care about designing learning environments
- On page 132 in *HPL*, the authors made a comparison between providing education and creating products in a factory. What were your reactions to this comparison?
- In your own words, briefly summarize the attributes of EITHER learner-centered learning environments OR knowledge-centered learning environments.
- Describe the broad relationship between engagement, motivation, and interest in relation to students learning STEM content.
- Summarize the role scaffolding plays in promoting student interest, motivation, and engagement.

They also read an article to supplement the earlier discussion of model-based reasoning (covered during the elbow design challenge) and completed reflection questions on this topic. To conclude the coursework, cohort 1 teachers worked in groups to develop their own lesson which introduced their classmates to a new tool or technology for teaching an integrated STEM lesson. The tinkering session design included four components:

- a detailed description of the tool or technology you selected and why it is important/interesting,
- an explanation of how using the tool or technology allows you to connect to two or more existing STEM standards,
- a pre-planned activity during which you pilot your tool or technology with the other members of the class, and
- a short debrief session where the remaining members of the class who participated in the lesson offer you feedback for improving the activity.

This gave the teachers ideas for supplemental technology to use in their own classes, and was intended to inspire the cohort 1 teachers as they began to plan integrated STEM lessons for the upcoming academic year.

There were also two field trips during this course, the first to the Meadows Museum on the SMU campus and the second to Spark! Adventures in Creativity. Both of these locations offered opportunities for the teachers to integrate information and experiences from traditionally different disciplines into a single educational learning opportunity.

Teacher Leadership Through Coaching

The afternoon sessions during the face-to-face academy were led by Dr. Gail Hartin, and additional material about coaching was presented in the post-online academy (see next section for details). The teachers began by answering the question 'Why coaching?' Up to 75% of change efforts fail, and coaching is a way to support people through a change process, allowing for growth and change (Reiss, 2012). The teachers discussed how coaching is different from mentoring, and then considered the different fields of study that led to the development of good coaching strategies being presented during this course.

The remainder of this session was spent learning about 12 different change strategies that coaches should employ. These change strategies included:

- Challenge assumptions
- Have a higher purpose
- Awareness of limiting thoughts
- Nix the negatives and naysayers
- Gather a group
- Emotionally connect to the goal
- Maintain momentum
- Ask, how can I? (go beyond the limits of the possible)
- See success smiling (maintaining positivity to achieve a goal)
- Turn talk to the future (use positive, future-focused words)
- Expect and welcome discomfort
- Remain relentlessly focused

The teachers discussed how people resist change when they feel that status, certainty, autonomy, relatedness and fairness are at stake. They also focused on the need for time, attention, repetition, and positive feedback when bringing about change.

During the next session the teachers learned about research concerning people's immunity to change. The teachers explored the reasons that individuals resist change, even to their own detriment, by considering examples from real-world scenarios. To add context to why individuals often resist change the teachers also learned about three plateaus of mental complexity: the socialized mind, the self-authoring mind, and the self-transforming mind.

Several characteristics describe each of these phases in mental development:

- Socialized mind – team player, faithful follower, aligning, seeks direction, reliant;
- Self-authoring mind – agenda-driven, leader learns to lead, own compass, own frame, problem solving, independent; and
- Self-transforming mind – meta-leader, leader leads to learn, multi-frame, holds contradictions, problem-finding, interdependent

The different types of challenges to change were then examined, and it was noted that different individuals and different situations may call for different approaches and solutions. The teachers developed their own 'Immunity to Change' map and considered how to use this information with their colleagues as they work to nurture change processes during the upcoming year.

The final component of the Teacher Leadership Through Coaching course was a conceptual framework for leading change called the Concern-Based Adoption Model (Roach, Kratochwill, & Frank, 2009). This model has six main strategies for facilitating a change process, which are:

- creating a shared vision of the change,
- planning/identifying needed resources,
- investing in professional learning,
- progress monitoring,
- providing assistance, and
- creating a context conducive to change

The Concern-Based Adoption Model also outlines the importance of understanding the individuals who are involved in and impacted by the change, and tailoring support based on their concerns and attitudes.

Three supplemental reading assignment were completed by the participating teachers. These covered the topics: competing values form obstacles to change, stages of concern and how addressing teacher concerns can aid innovation, and a discussion about the different roles that individuals take in the school reform process (from trailblazers to settlers to saboteurs).

Assignments for this section of the face-to-face academy included in class reflection and discussions, a peer-coaching project, a reflection paper, and a final exam.

Professional Learning Communities

The final component of the face-to-face academy was an in-depth exploration of PLCs led by Alain Mota (please see Appendix A for a full presenter biography). Although all Dallas ISD schools have identified time for teachers to participate in PLC meetings, it is common to find teachers who do not utilize this time as a true PLC or who do not understand how this protected time can impact and benefit student outcomes. The main components of the PLC training during Academy 3 were:

- the three purposes of PLCs,
- using protocols and agendas to facilitate PLCs,
- getting PLCs started,
- providing feedback to peers, and
- modeling productive PLCs.

The session began with teachers reflecting on readings that they had completed before coming to class. The main topics were a) what is a PLC? b) professional development vs. professional learning, and c) strategies for facilitating discussion. The teachers divided into groups and utilized a protocol to deconstruct and then share the main point of the readings. The purposes of PLCs were identified and defined using the big ideas and essential tasks inherent in all meetings.

The teachers then spent time individually considering the PLC meetings that they had attended in the past and identifying strong meeting components that were worthwhile compared to weak aspects that caused the time being spent to fall short of optimal productivity. The discussion was then directed to the use of protocols, and the participating teachers considered how a protocol could help alleviate some of the issues that they had previously identified. Specifically, the teachers considered facilitation role, the time structure, and required norms.

When talking about norms it was noted that often individual participants may take certain norms for granted, and that this may cause friction and stress during the PLC if other members do not have the same viewpoint. It is important to explicitly determine what norms are required for the productive and collaborative use of PLC time (Easton, 2009). The use of agendas and templates was also discussed, as these are mechanisms that can be useful for maintaining the structure of a PLC and help ensure that the stated goals are being achieved.

Next, the teachers in cohort 1 participated in a simulation of PLC meeting launchers. Each group was assigned to answer a different question. This discussion simulated how trust factors in to PLC meetings. The question each of the groups answered was a meeting launcher that did not have risk, invited risk, or encouraged risk taking. To further emphasize the importance of trust, the teachers read the 2018 article A matter of trust by Harrison Berg, Connolly, Lee, and Fairley about how a school in Boston developed the relational trust of its staff as a means for improving teacher retention, student academic growth, and the institution’s instructional culture.

The PLC training session concluded with specific details about warm and cool feedback, the Four A's protocol, the Last Word protocol, the Tuning protocol, the Consultancy protocol, and the Charette protocol (Venables, 2011). The use of protocols helps support groups in achieving deep understanding through dialogue, leads to more effective decision making and problem solving, and allows teachers to explore artifacts (such as student work, educators practice items, and educational texts) (Easton, 2009). These protocols are intended for use during the PLC meetings that the cohort 1 teachers will be facilitating during the upcoming academic year.

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. The activities and reading assignments were associated with the Teacher Leadership through Coaching course. Three main strategies were emphasized during the online modules following the face-to-face Academy 3 including: The Myth of Averages, Team Building, and Troubleshooting Common Obstacles. The focus of these strategies was for teachers to explore how the real-world factors can impact collaboration, team building, and PLCs. The following section describes the main emphases of the online modules that teachers completed after attending the face-to-face Academy 3 sessions.

The Myth of Averages

The concept covered in this section of the post-online academy began by analyzing how designing a fighter jet cockpit based on the size of the average pilot was limiting the success rates within that field. The Air Force conducted a study and found that a one-size-fits-all approach was not ideal, because it limited the types of individuals that could become pilots. Todd Rose, the co-founder and president of the Center for Individual Opportunity and faculty member at the Harvard Graduate School of Education, presented a TED Talk and then compared this example to the classroom. He noted that many educational classrooms are identical for a diverse array of students and asserted that this is not likely the best way to achieve each student's highest achievement. During his talk, further arguments are made for the use of technology as a powerful tool for differentiation. Specifically, how technology can help students overcome personal challenges in certain areas, such as reading level, so that they can excel in a different content area, such as science. The teachers in cohort 1 discussed how the simple solution of 'adjustable seats' reformed the fighter jet industry, allowing more individuals to be successful, and considered what types of 'adjustable seats' were present, or needed, in their own classrooms.

Team Building

Once the importance of collaboration was established by the teachers in cohort 1, they read a book chapter that gave several examples of considerations that must be decided upon when building productive PLC teams. When developing PLCs, schools need to consider the needs of their students, and specific demographic information such as number of teachers, subjects taught, and grade levels taught (Venables, 2011). Next, it was recommended that a coaches' PLC be established. This would allow the leaders of each individual PLC on campus to meet with and collaborate with other team leaders. The ultimate goal for a coaches PLC is to "form a necessary support system which enables them to better lead their own PLCs" (Venables, 2011, p. 22).

Specific focus was given to characteristics of good coaches, and behaviors that should be avoided.

The online portion of Academy 3 included several different ice breaker activities that could help cohort 1 teachers identify the different types of individuals in their PLC groups. The teachers discussed how it is important to know each individual in order to coach them efficiently and successfully.

The next portion of this session focused on group norms. As mentioned previously, assuming that all members of a PLC have the same norms can become problematic, so it is imperative to explicitly outline the behaviors that are required for productivity. The cohort 1 teachers were given a protocol that could be followed during a PLC meeting in which the group was developing and setting norms for future meetings.

The teachers participated in a reflective discussion board post by answering the following questions regarding their coaching persona.

- What are two desirable characteristics that you personally have?
- What are two undesirable characteristics that you have? Or what are two desirable characteristics that you would like to improve upon?
- How do you think being aware of you desirable or growth characteristics can support you as you engage with your peers as a colleague or leader?

The teachers concluded this section of the post-online academy by sharing a team building activity with the rest of the cohort, and participating in a simulated conversation with their administrator about the importance of norm setting and protocol use within the PLC.

Troubleshooting Common Obstacles

The final concept covered in Academy 3 was the ways in which a facilitator or coach could mitigate common challenges and obstacles. The teachers read a chapter from Venables 2011 book *The Practice of Authentic PLCs* and reflected on which of the challenges they had experienced in their own PLCs and which different solutions may work best at their own schools. The major obstacles that the book outlines are:

- reluctant and resistant teachers,
- managing conflict and disagreement,
- pushing a conversation deeper, and
- retooling existing ineffective PLCs

The chapter concludes with a message to principals, which can also be relevant to any administrator overseeing PLCs. It offers suggestions for how to shift the habits within an existing PLC such as train/change the coach, change the physical environment, increase team building, conduct a book study, and/or conduct an assessment.

In summary, the content of both the online and face-to-face portions of Academy 3 supported the cohort 1 teachers in furthering their understanding of the four foundational pillars. Pedagogical strategies that incorporated the scientific process standards and science content knowledge were presented, and the teachers had opportunities to develop lessons and strategies that they could directly implement into their classrooms and PLC meetings. SEL was incorporated throughout Academy 3, which offered multiple strategies for differentiating instruction for a wide variety of learners and teachers. Many of these strategies specifically utilized active learning inquiry-based instruction as a mechanism for increasing student engagement, interest, and ultimately success.

Participating Teachers

Table 1 shows that in year 2017-2018, there was a total of 16 teachers. Of that total, there were 4 male teachers and 12 female teachers. According to race, there were 9 teachers who identified as Black and 7 teachers who identified as White. In ethnicity, there were 4 teachers that identified as Hispanic or Latino, compared to 12 teachers who were not Hispanic or Latino. In year 2018-2019, there was a total of 12 teachers. Of that total, there were 3 male teachers and 9 female teachers. According to race, there were 7 teachers who identified as Black and 5 teachers who identified as White. In ethnicity, there were 3 teachers who identified as Hispanic or Latino, compared to 9 teachers who were not Hispanic or Latino.

In 2019-20, there was a total of 9 teachers. Two teachers (22%) identified as female, and seven teachers (78%) identified as male. Five teachers (56%) identified their race as Black, and four teachers (44%) identified their race as White. Two teachers (22%) identified their ethnicity as Hispanic of Latino, and seven (78%) stated they were not Hispanic or Latino.

Table 1

Cohort 1 Teacher demographic information

Characteristic		2017-18 # of Teachers	2017-18 % of Teachers	2018-19 # of Teachers	2018-19 % of Teachers	2019-20 # of Teachers	2019-20 % of Teachers
Gender	Male	4	25%	3	25%	2	22%
	Female	12	75%	9	75%	7	78%
Race	Alaska Native	0	0%	0	0%	0	0%
	Asian	0	0%	0	0%	0	0%
	Black	9	56%	7	58%	5	56%
	Native Hawaiian	0	0%	0	0%	0	0%
	Other Pacific Islander	0	0%	0	0%	0	0%
	White	7	44%	5	42%	4	44%
Ethnicity	Hispanic or Latino	4	25%	3	25%	2	22%
	Not Hispanic or Latino	12	75%	9	75%	7	78%
Total		16	100%	12	100%	9	100%

In both table 2 and figure 2, there is a notable increase between the years of 2017-18 to years 2018-2019 in the years that teachers worked in other careers. There could be numerous reasons for this; some teachers have two jobs or picked up an additional trade of some sort or exiting teachers may have had a lower mean number of years in other careers, resulting in a lower observed mean in 2017-18.

The mean years in education has remained consistent for all three time points. Mean years teaching and mean years teaching science both decreased slightly between 2018-19 and 2019-20, while years in other careers and years at current school, means each decreased by more than one.

Table 2

Cohort 1 Teachers' work experience

	2017-18 N=16	**2018-19** N=12	**2019-20** N=9
	Mean # of Years (*SD*)	Mean # of Years (*SD*)	Mean # of Years (*SD*)
Years in education	5.7 (4.7)	5.7 (3.3)	5.7 (1.9)
Years teaching	5.5 (4.8)	5.6 (3.4)	5.4 (1.7)
Years teaching science	5.2 (4.8)	5.2 (3.0)	5.0 (1.5)
Years in other careers	7.8 (6.6)	8.9 (6.1)	7.2 (7.0)
Years at current school	4.0 (3.1)	4.8 (3.4)	3.7 (2.8)

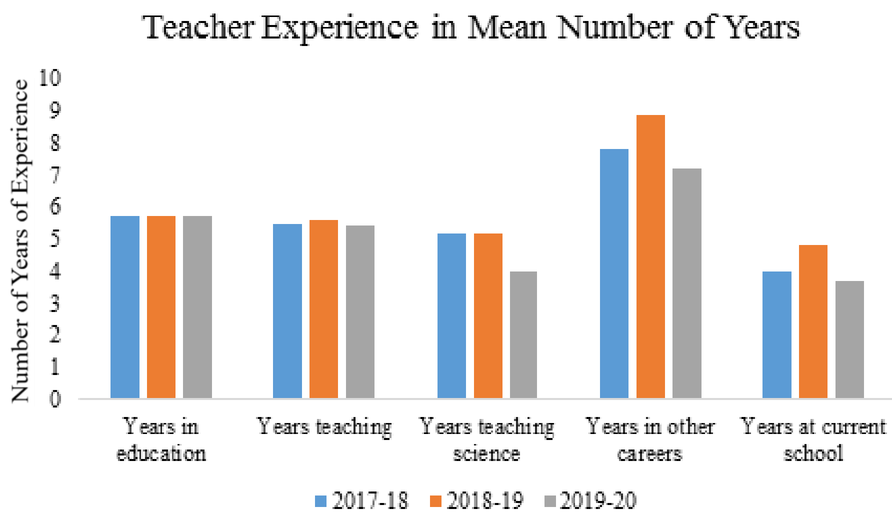

Figure 2. Cohort 1 teacher experience

Table 3 shows that the majority of cohort 1 teachers have a bachelor's degree in Biology. From 2017-18 to 2018-19, the number of teachers with a degree in biology decreased from six teachers to two teachers.

Table 3

Cohort 1 Major for participating teachers' bachelor's degrees

Bachelor's Degree	**2017-18** # of Teachers	**2018-19** # of Teachers	**2019-20** # of Teachers
Biochemistry	1	1	1
Biology	6	2	2
Business Administration	1	1	0
English	1	1	1
Environmental Analysis	1	1	1
Interdisciplinary Studies	1	1	1
Kinesiology	1	1	1
Mass Communication	1	1	1
Mathematics	1	1	0
Organizational Development	1	1	1
Psychology	1	1	0
Total	16	12	9

Over the three timepoints shown in table 4, there has been an increase in the number of teachers enrolled in masters or doctorate programs, and a decrease in the number of teachers who completed master's or doctorate programs. This may be because the majority of cohort 1 is enrolled in the SMU Master's program.

Table 4

Cohort 1 Teachers Enrolled or Completed Graduate Work

Degree Type	2017-18 N=16		2018-19 N=12		2019-20 N=9	
	# of Teachers	% of Teachers	# of Teachers	% of Teachers	# of Teachers	% of Teachers
Currently Enrolled in Master's or Doctorate	0	0%	2	17%	8	89%
Completed Master's	4	25%	2	16%	1	11%
Completed Doctorate	0	0%	0	0%	0	0%

Table 5 shows that the number certifications the teachers held each year of the STEM Academy. In 2019-20, six teachers had one certification and three teachers had two certifications.

Table 5

Cohort 1 Number of certifications for participating teachers

Certifications	2017-18 # of Teachers	2018-19 # of Teachers	2019-20 # of Teachers
1 subject-area	10	8	6
2 subject-area	5	4	3
3 subject-area	1	0	0
	16	12	9

In the Professional Development sector, between years, teachers began spending more time on their assigned topics. The increase could be due to the participants having more experience from prior years or the coaching they are being given.

Tables 6 and 7 show the number of professional development hours by topic that cohort 1 teachers participated in historically. Table 8 and Figure 3 include the professional development by topic for the cohort 1 teachers who participated in Academy 3. In 2019-20, the majority of teachers reported less than 6 hours of professional development in science content, English language learners, and students with disabilities. In 2018-19, all but one teacher reported receiving seven or more hours of professional development in project-based learning and maker-based instruction; however, the majority of teachers in 2019-20 received zero hours of professional development in project-based learning and maker-based instruction. Hours of professional development decreased in all listed topics from 2018-19 to 2019-20.

Table 6

Cohort 1 2017-18 Professional development by topic

Topic	None	Less than 6 Hours	7-15 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
Other content areas	3	5	6	0	2
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

N=16

Table 7

Cohort 1 2018-19 Professional development by topic

Topic	None	Less than 6 Hours	7-15 Hours	16-35 Hours	More than 35 Hours
Science content	0	0	1	3	8
Project-Based Learning	1	0	3	4	4
Maker-Based Instruction	1	0	3	4	4
Other content areas	3	3	5	1	0
Social and Emotional Learning	1	2	5	2	2
Students with disabilities	2	4	5	1	0
English-language learners	1	3	3	5	0

N=12

Table 8

Cohort 1 2019-20 Professional development by topic

Topic	None	Less than 6 Hours	6-15 Hours	16-35 Hours	More than 35 Hours
Science content	0	3	3	2	1
Project-Based Learning	4	3	1	0	1
Maker-Based Instruction	5	2	1	0	1
Other content areas	6	2	0	0	1
Social and Emotional Learning	1	2	5	0	1
Students with disabilities	2	6	0	0	1
English-language learners	1	5	1	1	1

N=9

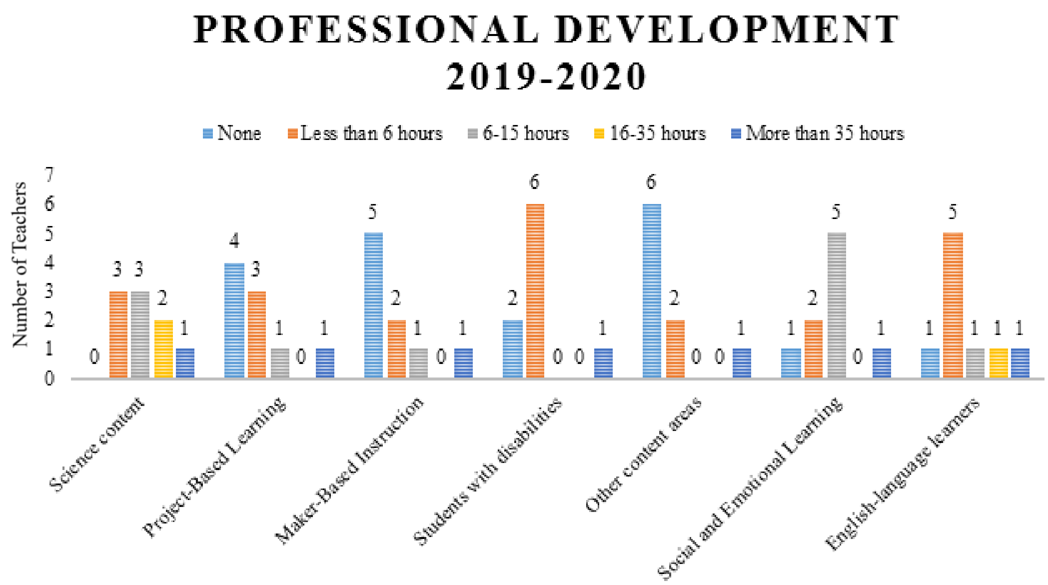

Figure 3. Cohort 1 professional development 2019-2020

Academy 3 Evaluation Survey

Following Academy 3, teachers completed the *STEM Academy for Teachers and Leaders: Academy 3 Evaluation Survey*, which included 15 questions, 12 of which had multiple components, and allowed teachers to report their level of agreement with statements about the quality of Academy 3. Items focused on understanding teachers' overall impressions of the Academy 3 structure, content, and speakers. The survey was administered via Qualtrics (Qualtrics, 2018) immediately following the implementation of Academy 3.

The results in the following section summarize the academy evaluation data collected following Academy 3 with cohort 1 teachers who continued in the program (n=10). Of the participating teachers, one was not a teacher, but rather a leader, and therefore not eligible to participate in the survey. Of the remaining nine, eight cohort 1 teachers completed the survey, resulting in a response rate of 89%. Academy 3 was implemented for the first time in the summer 2019; 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 *active learning* strategies in the classroom, which includes PBL, MBI, and the 5E model, (c) specific to application of activities that teach and incorporate the *scientific process standards*, (d) specific to *content knowledge*, (e) specific to *socio-emotional learning*, (f) specific to *community-based STEM education resources*, and (g) specific to *teacher leadership*. We examine teachers' perceptions quantitatively by looking at agreement rates. It is important to note that the sample size for cohort 1 during the third year (2019-20) is 8 teachers. Although 10 participated in the summer academy, one holds a position as an instructional coach and did not complete the survey since she will not be teaching classes. Of the nine classroom teacher participants only eight responded to the survey.

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, socio-emotional learning, community-based STEM education resources, and teacher leadership).

Overall

Figure 4 shows the percent of cohort 1 teachers who agreed or strongly agreed with statements about Academy 3 overall. These statements inquired about the extent to which teachers agreed that the academy was interactive, would improve their science instruction, built on previous year's content, met their expectations, and was a valuable professional development opportunity. Teachers responded with high agreement to all five of these statements, as evidenced by the fact that 100% of the teachers (8/8 teachers) either agreed or strongly agreed with the statements about the overall academy. In fact, 100% of teachers strongly agreed that the academy was interactive, while the other statements had between 63% (5/8 teachers) and 88% (7/8 teachers) strongly agree and the remaining teachers agree.

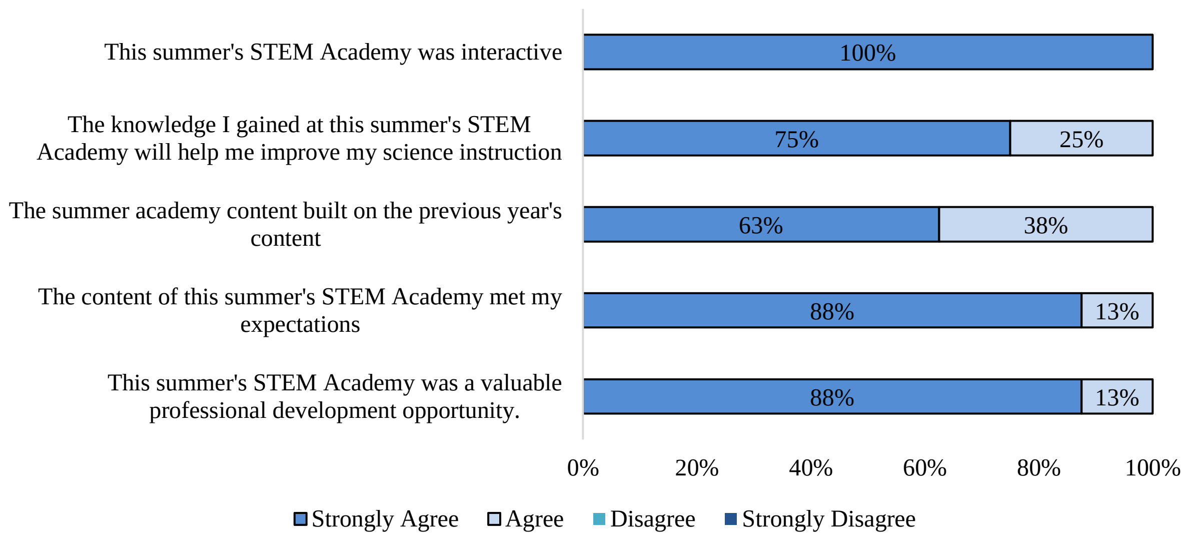

Figure 4. Percent of teachers who agreed or strongly agreed with overall statements about Academy 3
Note: Sample includes 8 Cohort 1 teachers.

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. Two teachers specifically mentioned general appreciation for Academy 3 stating, "I learned a lot and will carry this knowledge into my classroom" and "learned so much, per usual!" One of these teachers also noted that she was "kind of sad it's my last summer."

One teacher (13%) identified an aspect of the overall academy that could be improved. She said that during the academy they should devote “less time [to] ‘playing’ with technologies (as much fun as that truly was!) and [devote] more time [to] designing actual lessons using the technology.”

Active Learning

Figures 5, 6, 7, and 8 show the percent of cohort 1 teachers who agreed or strongly agreed with statements specific to pedagogical strategies aimed at fostering active learning through inquiry in the classroom. Several integrated aspects of instruction are critical for effective inquiry instruction. The aspects included during Academy 3 were STEM integration, learning environment design, 5E, MBI, and PBL. A main goal of Academy 3 was to provide teachers with high-quality information and deepen their understanding of these aspects as critical for effective active learning through inquiry instruction. The statements below inquired about the extent to which teachers agreed that Academy 3 deepened their understanding of the inquiry strategies and provided high-quality content about these inquiry strategies. Additionally, the teachers indicated the extent to which they agreed that Academy 3 provided them with the tools needed to apply these strategies in their classroom and that the follow up coaching would help them apply these strategies in their science instruction.

Similar to Figure 4, 100% of cohort 1 teachers (8/8 teachers) either agreed or strongly agreed that Academy 3 effectively delivered high-quality information about and deepened their understanding of STEM integration. All of the teachers also agreed that the speakers delivered high-quality information about learning environment design and the 5E method.

However, 13% (1/8 teachers) to 25% (2/8 teachers) disagreed that Academy 3 deepened their understanding about learning environment design, 5E, MBI, and PBL (Figure 5). Two of the eight teachers (25%) disagreed that high-quality information about MBI was delivered and 13% (1/8 teachers) disagreed that high-quality information about PBL was delivered (Figure 6).

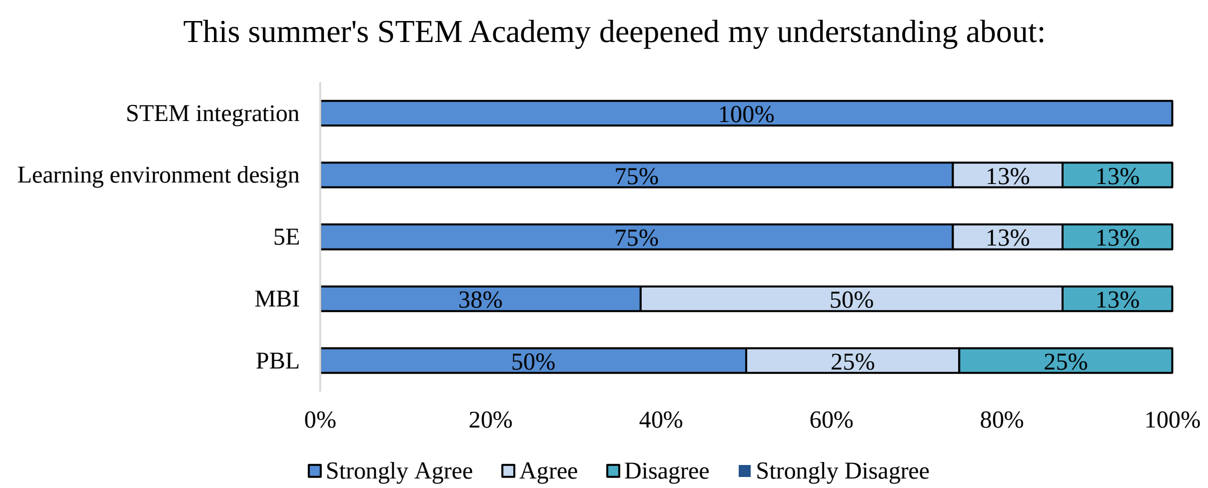

Figure 5. Percent of teachers who strongly agreed, agreed, or disagreed with statements about deepening understanding of active learning pedagogical strategies during Academy 3

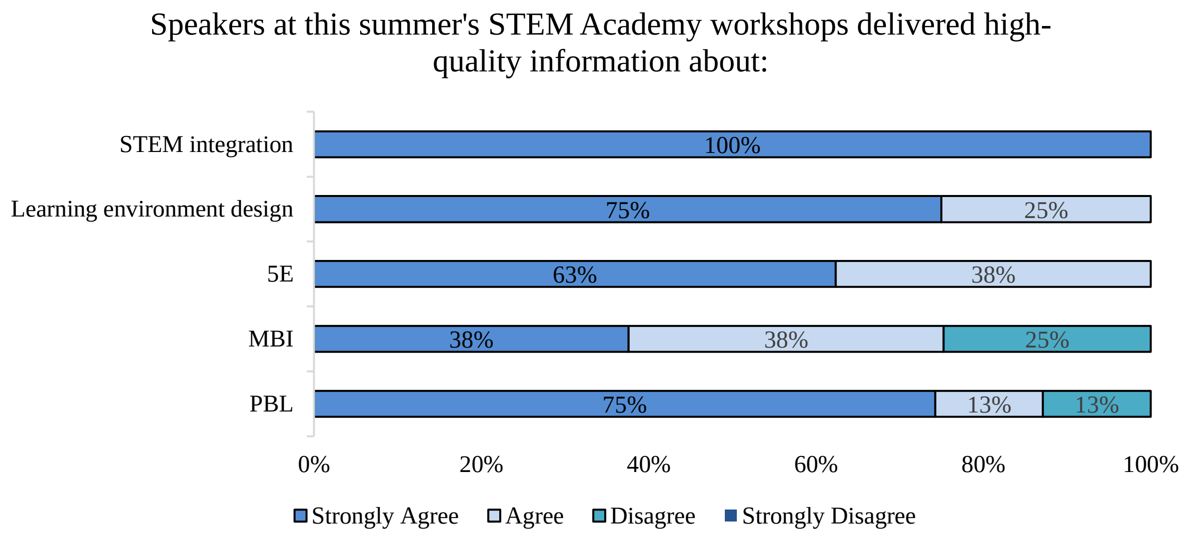

Figure 6. Percent of teachers who strongly agreed, agreed, or disagreed with statements about speakers on the main active learning topics during Academy 3

Teachers agreed that Academy 3 provided them with the tools needed to apply these strategies in their classroom. Figure 7 shows that 100% (8/8 teachers) agreed or strongly agreed regarding STEM integration and learning environment design. Also, seven out of eight teachers (88%) agreed or strongly agreed that they were provided with the tools to apply 5E in their classroom and six out of eight teachers (75%) agreed or strongly agreed that they were provided with the tools to apply both MBI and PBL in their classrooms (Figure 7).

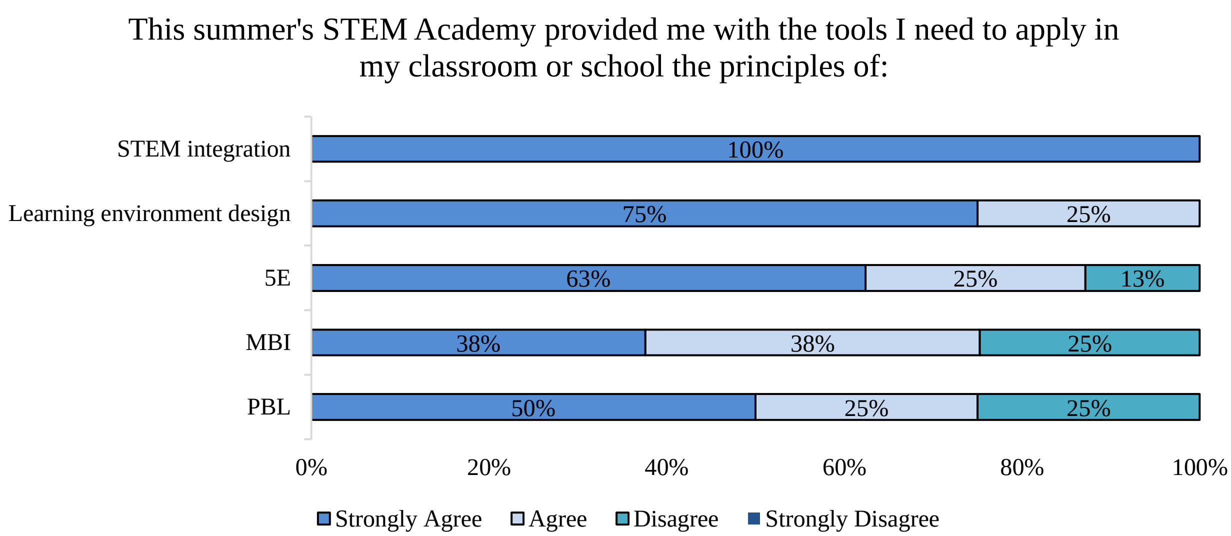

Figure 7. Percent of teachers who strongly agreed, agreed, or disagreed with statements about Academy 3 providing the tools needed to apply active learning strategies in the classroom

Finally, teachers agreed that the follow-up coaching and support planned for the upcoming school year would help them apply these active learning strategies in their classroom, while 88% (7/8 teachers) agreed or strongly agreed regarding STEM integration, learning environment design, and the 5E method (Figure 8). 75% (6/8 teachers) agreed or strongly agreed that the planned coaching and support would help them apply both MBI and PBL in their classrooms (Figure 8).

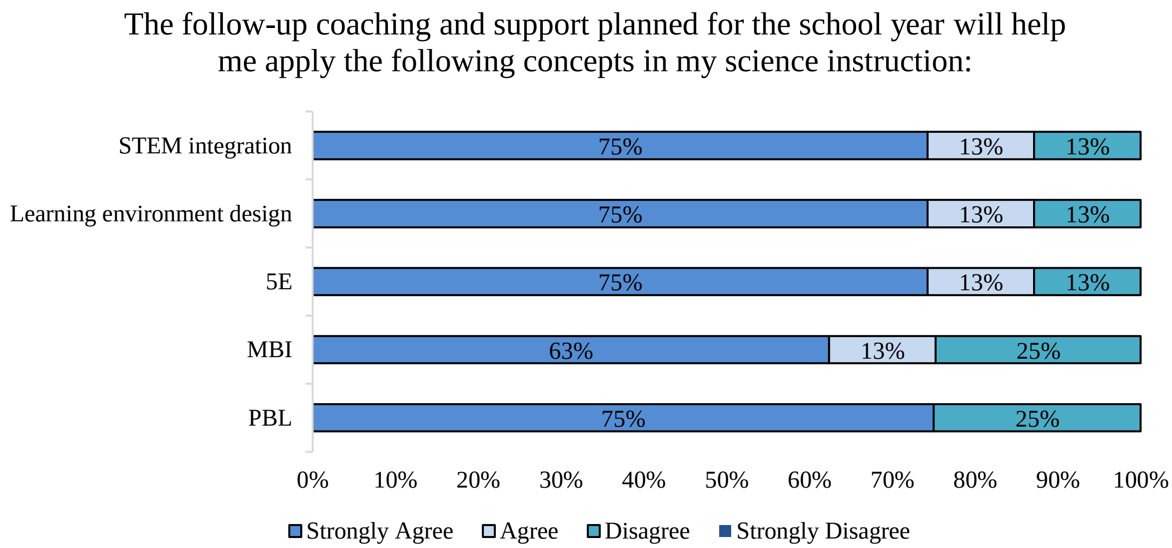

Figure 8. Percent of teachers who strongly agreed, agreed, or disagreed with statements about follow-up coaching helping them apply active learning strategies in the classroom

On the open-ended survey items, two teachers (25%) explicitly listed STEM integration as an area of Academy 3 that was the most useful. None of the teachers mentioned any areas for improvement within the active learning through inquiry content.

Process Standards

Academy 3 was comprised of three main components (i.e., active learning, PLCs, and teacher leadership). Effective implementation of active learning through inquiry strategies requires an in depth understanding of the scientific process standards. When active learning instructional strategies are integrated in the science classroom, the students are learning, practicing, and utilizing the scientific process standards (NRC, 2000). 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 active learning instructional strategies throughout Academy 3.

Figure 9 shows the percent of teachers who strongly agreed, agreed, or disagreed that Academy 3 provided them with high-quality information about the process standards from speakers, adequately planned follow-up coaching and support for implementation of the process standards in the classroom, provided the tools necessary to apply the process standards in the classroom, and deepened their understanding of the scientific process standards in general. Overall, 88% of the teachers (7/8 teachers) agreed or strongly agreed with the statements about high-quality information, follow-up coaching, and provided tools (Figure 9). All of the teachers (8/8) agreed or strongly agreed that the STEM Academy deepened their understanding of the scientific process standards (Figure 9).

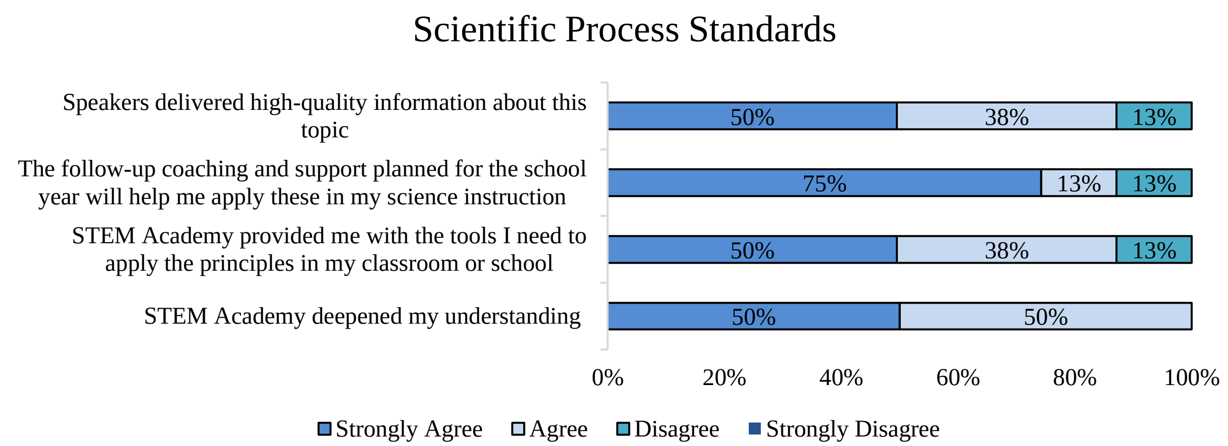

Figure 9. Percent of teachers who strongly agreed, agreed, or disagreed with statements about the incorporation of the scientific process standards in Academy 3.

On the open-ended items, only one teacher explicitly mentioned the scientific process standards stating that "STEM integration specifically with our TEKS" was an area in which Academy 3 could improve. However, as mentioned above, all of the teachers made favorable comments regarding active learning through inquiry instruction more broadly, which utilizes the scientific process standards.

Content Knowledge

Figure 10 shows that between 88% (7/8 teachers) and 75% (6/8 teachers) of cohort 1 teachers agreed or strongly agreed with statements about the incorporation of science content knowledge in Academy 3. The remaining teachers (13-25%) disagreed with these statements.

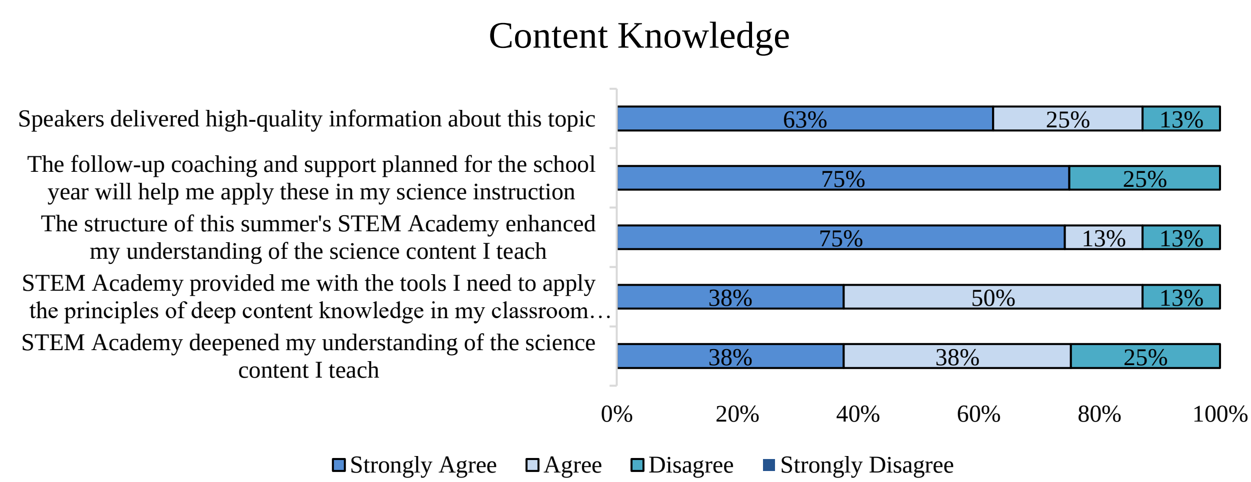

Figure 10. Percent of teachers who strongly agreed, agreed, or disagreed with statements about the incorporation of content knowledge in Academy 3.

Specifically, 88% (7/8 teachers) of cohort 1 agreed or strongly agreed that speakers delivered high-quality information about content knowledge, that the structure of the academy enhanced their understanding of the science content, and that Academy 3 provided them with the tools they need to apply the principles of content knowledge in their classroom or school. Six out of eight (75%) teachers agreed or strongly agreed that Academy 3 deepened their understanding of the science content they teach and that the follow-up coaching would help them when applying content knowledge in the classroom.

On the open-ended response questions, the teachers did not explicitly reference the content knowledge associated with Academy 3.

Social Emotional Learning

Attending to diverse student needs with an emphasis on SEL addressed the core pillar of differentiation throughout Academy 3, which is integral to the implementation of active learning. In order to attend to the varying needs of the student populations with whom teachers work 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 11 shows the percent of cohort 1 teachers who strongly agreed, agreed, or disagreed with statements about SEL during Academy 3. All of the teachers agreed or strongly agreed that speakers delivered high-quality information regarding SEL, that Academy 3 provided them with the necessary tools to implement SEL strategies in the classroom, and that their understanding of SEL was deepened (Figure 11). Additionally, 88% (7/8 teachers) agreed or strongly agreed that the on-going support would help them incorporate SEL strategies into their science curriculum (Figure 11). On the open-ended response questions, the teachers did not explicitly reference SEL strategies associated with Academy 3.

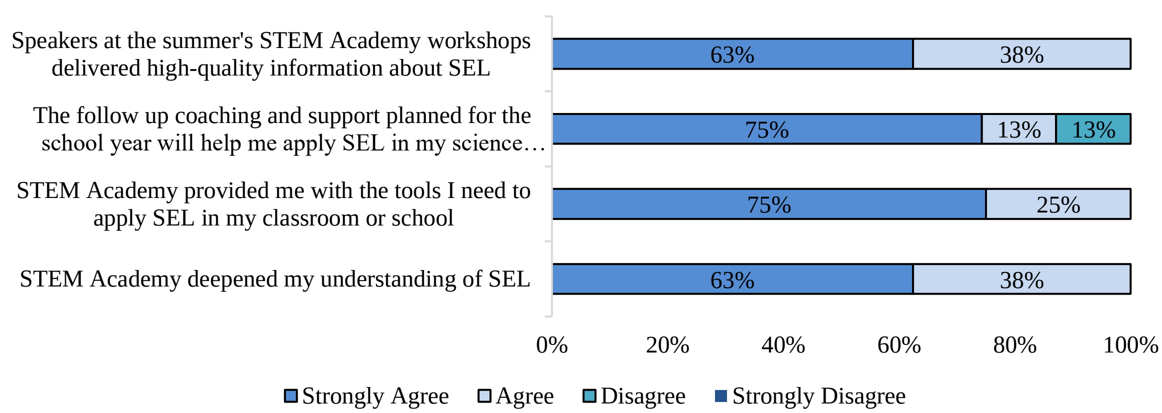

Figure 11. Percent of teachers who strongly agreed, agreed, or disagreed with statements about SEL in Academy 3.

Community-Based STEM Education Resources

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). In addition to the two field trips during Academy 3, the teachers were exposed to various other community-based STEM resources that they could incorporate into their classroom instruction in multiple ways. 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.

Figure 12 shows that when asked about the extent to which they agreed with statements about the incorporation of community-based STEM education resources, 88% (7/8 teachers) of cohort 1 responded favorably by agreeing or strongly agreeing. These teachers felt that speakers delivered high-quality information that deepened their understanding of community-based resources. They also agreed or strongly agreed that they were provided with the necessary tools to utilize these resources in their classrooms, and that the planned coaching and support would further facilitate use of these resources in their science instruction.

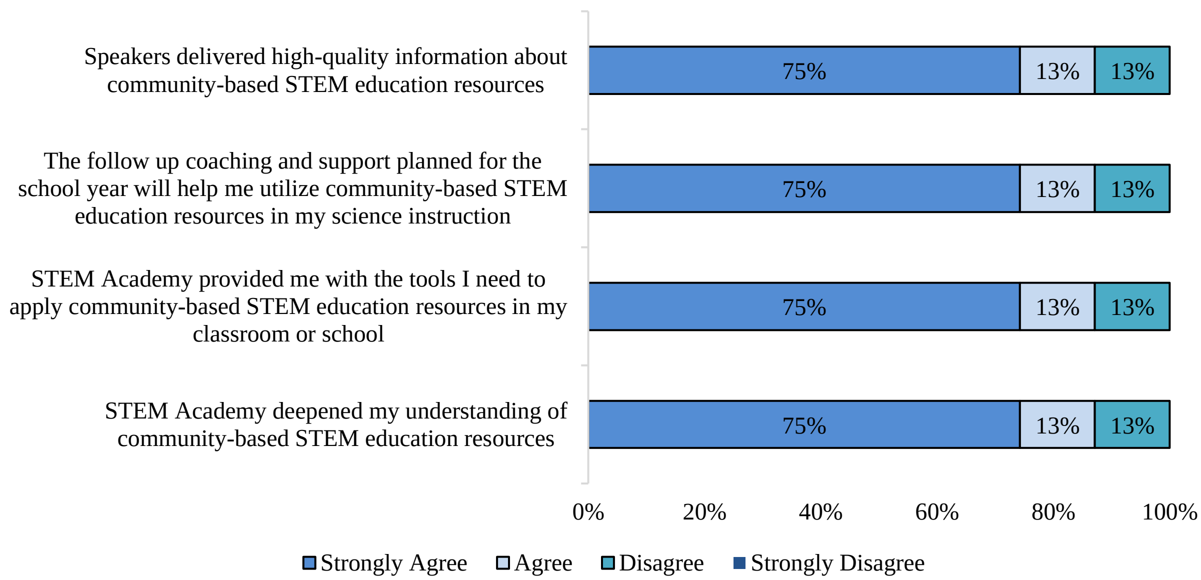

Figure 12. Percent of teachers who strongly agreed, agreed, or disagreed with statements about community-based STEM education resources in Academy 3.

Teacher Leadership

The final component of Academy 3 employed a variety of strategies to develop teacher leadership skills. As cohort 1 progressed through the STEM Academy, they had been asked to take on a more proactive leadership role within their departments and on their campuses. As mentioned previously, Academy 3 utilized several mechanisms to develop the participating teachers as leaders, and Figure 13 indicates the extent to which they agreed with statements regarding leadership development during Academy 3.

Seven out of eight (88%) teachers strongly agreed that the follow-up coaching and support would help them apply the principles of PLCs, teacher coaching, and effective communication learned during Academy 3 in their classrooms (Figure 13). 13% (1/8 teachers) of cohort 1 disagreed with these statements.

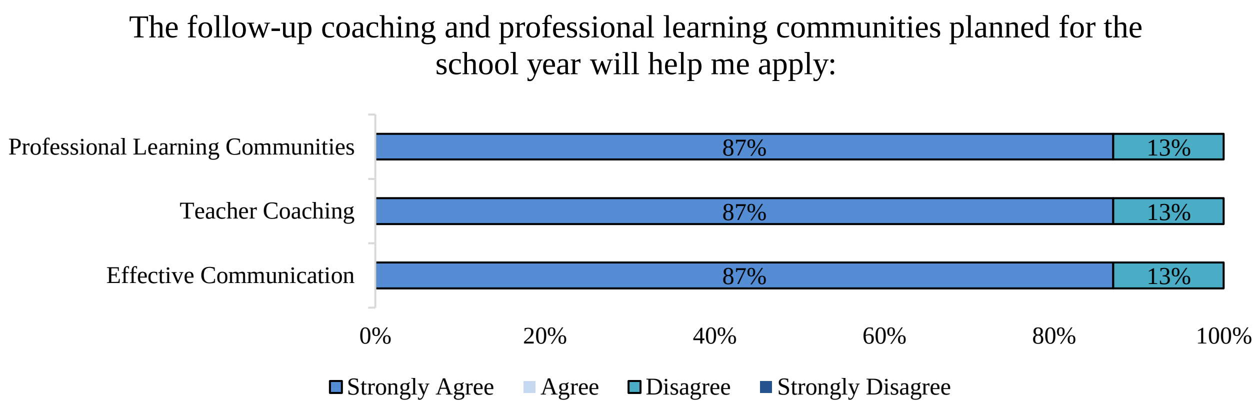

Figure 13. Percent of teachers who strongly agreed, agreed, or disagreed with statements about the planned follow-up coaching and its impact on the application of teacher leadership opportunities.

Furthermore, 100% (8/8 teachers) strongly agreed that Academy 3 deepened their understanding of PLCs, teacher coaching, and effective communication (Figure 14). All of the teachers (8/8) strongly agreed that Academy 3 provided the tools necessary for the implementation of PLCs, teacher coaching, and effective communication in their classrooms or on their campuses (Figure 14). All of the teachers (8/8) strongly agreed that speakers at Academy 3 provided high-quality information about PLCs, teacher coaching, and effective communication (Figure 14). Additionally, 100% (8/8 teachers) strongly agreed that the knowledge they gained during Academy 3 would help them improve other teachers' instruction (Figure 14).

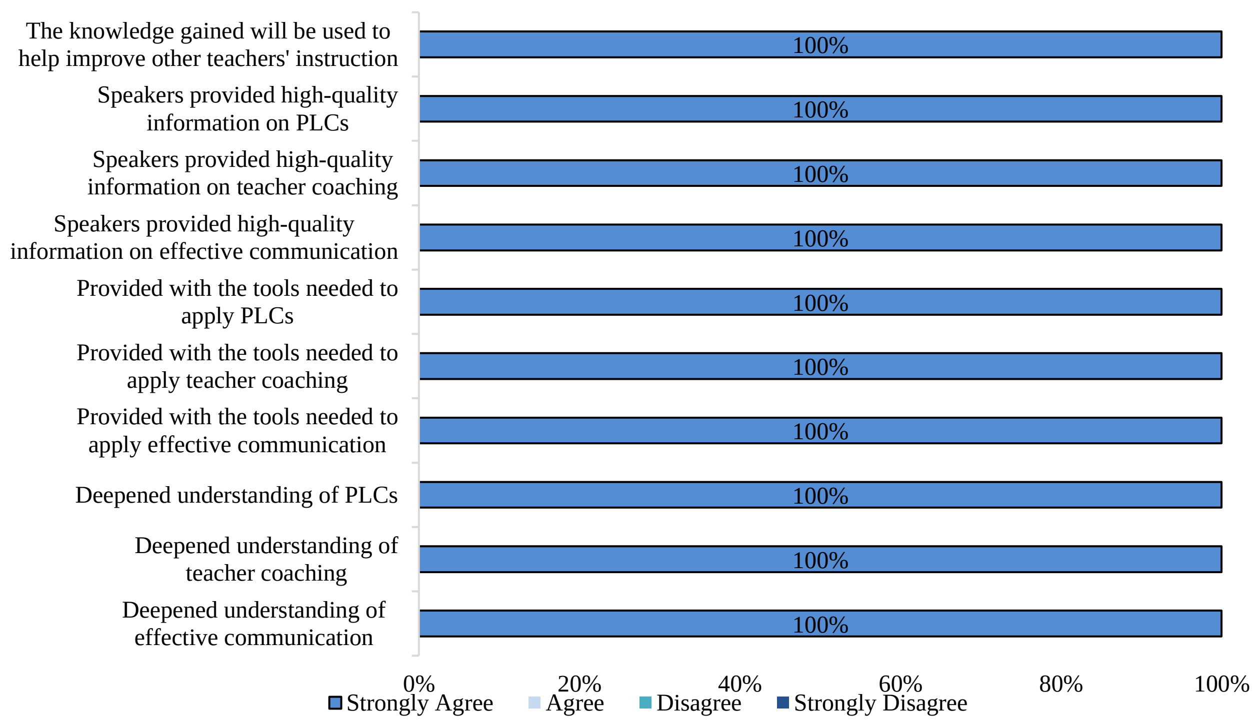

Figure 14. Statements about Academy 3 components that affected the delivery of information about PLCs, teacher coaching, and effective communication.

On the open response questions, seven out of eight (88%) teachers specifically mentioned the coaching training as an aspect of the academy that was the most useful, with one commenting that “as I learned what the role of a coach is… I can better support my science team in the future.” Other comments described the coaching and leadership training as “excellent” and “incredible.” One teacher mentioned that this portion of the academy “made us better communicators by increasing our awareness.” She went on to say, “I have a better understanding of the importance of PLCs” and that “if you do them correctly, it can be very beneficial for student achievement.” This component of Academy 3 yielded the most overwhelmingly positive responses on the teacher survey.

Summary

Overall. All of the cohort 1 teachers (8/8) participating in Academy 3 indicated that they agreed or strongly agreed that the academy was interactive, would improve their science instruction, built on previous year’s content, met their expectations, and was a valuable professional development opportunity.

Academy Content. The content of Academy 3, 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, PLC delivery strategies, teacher leadership development, and connections to community-based STEM education resources. These core instructional strategies were connected to the foundational pillars, which included active learning through inquiry, differentiation, content knowledge, and scientific process standards. All of the teachers agreed or strongly agreed that Academy 3 was a valuable professional development opportunity that met their expectations.

Active Learning. Teachers responded favorably to questions about inquiry, with 75-100% (out of 8) agreeing or strongly agreeing that the STEM Academy both deepened their understanding of and provided the necessary tools to implement active learning inquiry strategies including STEM integration, learning environment design, 5E, MBI, and PBL. Additionally, 75-100% of teachers agreed or strongly agreed that the speakers at the STEM Academy delivered high-quality information about STEM integration, learning environment design, 5E, MBI, and PBL and that the planned follow-up coaching would further support their classroom goals related to active learning.

Process Standards. The teachers needed an understanding of the process standards in order to implement the inquiry-based pedagogical strategies presented during Academy 3. Seven out of eight (88%) teachers agreed or strongly agreed that they were presented with high-quality information about the process standards, that the follow-up coaching would support their implementation of the process standards, and that they were provided with the necessary tools for this implementation to be successful. Furthermore, 100% (8/8 teachers) agreed or strongly agreed that the STEM Academy deepened their understanding of the scientific process standards.

Content Knowledge. Between seven out of eight (88%) and six out of eight (75%) cohort 1 teachers agreed or strongly agreed with statements about the incorporation of science content knowledge in Academy 3. Specifically, Seven out of eight (88%) teachers in cohort 1 agreed or strongly agreed that speakers delivered high-quality information about content knowledge, that the structure of the academy enhanced their understanding of the science content, and that Academy 3 provided them with the tools they need to apply the principles of content knowledge in their classroom or school. Six out of eight (75%) teachers agreed or strongly agreed that Academy 3 deepened their understanding of the science content they teach and that the follow-up coaching would help them when applying content knowledge in the classroom.

Social Emotional Learning and Community-Based STEM Resources. 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, Academy 3 exposed teachers to experiential learning opportunities that promote differentiation by engaging students in activities outside of the classroom and drawing real world connections. All of the teachers agreed or strongly agreed that speakers delivered high-quality information regarding SEL, that Academy 3 provided them with the necessary tools to implement SEL strategies in the classroom, and that their understanding of SEL was deepened. Additionally, seven out of eight (88%) teachers agreed or strongly agreed that the on-going support would help them incorporate SEL strategies into their science curriculum. Seven out of eight (88%) teachers felt that speakers delivered high-quality information that deepened their understanding of community-based resources. Seven out of eight (88%) teachers also agreed or strongly agreed that they were provided with the necessary tools to utilize these resources in their classrooms, and that the planned coaching and support would further facilitate use of community-based STEM education resources in their science instruction.

Teacher Leadership. Seven out of eight (88%) teachers strongly agreed that the follow-up coaching and support would help them apply the principles of PLCs, teacher coaching, and effective communication learned during Academy 3 in their classrooms while also deepening their understanding of these topics. All of the teachers strongly agreed that Academy 3 provided the tools necessary for the implementation of PLCs, teacher coaching, and effective communication in their classrooms or on their campuses and that speakers provided high-quality information about these topics. Additionally, 100% (8/8 teachers) strongly agreed that the knowledge they gained during Academy 3 would help them improve other teachers' instruction. Seven out of eight (88%) teachers specifically mentioned the coaching training as an aspect of the academy that was the most useful, and this component of Academy 3 yielded the most overwhelmingly positive responses on the teacher survey.

Conclusion and Recommendations

Three recommendations for improving Academy 3 in the future are suggested, based on the results and analysis within this report.

1. The core structure and activities within Academy 3, especially the emphasis on teacher leadership and coaching, should continue with minor, if any, adjustments in future years.

This recommendation is based on teachers' overwhelmingly positive perceptions of Academy 3. Additionally, on open ended items, seven of the eight teachers (88%) explicitly referenced coaching as one of the most helpful aspects of Academy 3.

2. The main aspect of Academy 3 that the teachers indicated was lacking concerns the connection of the presented material and strategies to the science content that the teachers cover in their classes. In the future, Academy 3 facilitators should make explicit connections to both the science content and the process standards in order to specifically exemplify the connection for participating teachers.

3. A final recommendation, which is drawn from the open-ended responses of the teachers, but which does not fit specifically into the content of Academy 3, and therefore was not mentioned previously, is the amount of required work outside of the hours that the teachers attended the face-to-face sessions. Two teachers mentioned that they spent significant time completing assignments outside of the time they were physically present, and future presentations of Academy 3 should attempt to minimize the time that teachers work at home after face-to-face sessions.

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Appendix A – Presenter Biographies

Gail Hartin: Dr. Gail Hartin's experience as a coach began when she served as a principal in the Highland Park Independent School District in Dallas, Texas. Her training and experience in coaching school personnel led to a faculty role at Southern Methodist University, where she has coached students, alumni, and faculty members, and has taught graduate courses in teacher preparation and principal preparation. She specializes in coaching educators who serve in leadership roles such as principal, department chair, and program director. In addition, she provides coaching services to private clients in areas such as church ministry, music, consulting, and mental health. Along with the Professional Certified Coach credential from the International Coach Federation, Gail holds certification as a Gallup Strengths Coach.

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.

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.

Appendix B – Academy 3 Teacher Evaluation Survey

To what extent do you agree with the following statements?

	Strongly Disagree	Disagree	Agree	Strongly Agree
1. This summer's STEM Academy was a valuable professional development opportunity.				
2. This summer's STEM Academy deepened my understanding of: ○ Project-based learning ○ Maker-based instruction ○ Social and emotional learning ○ 5E lesson design ○ The scientific process standards ○ Science content knowledge ○ Community-based STEM education resources ○ Learning environment design ○ STEM integration ○ Effective communication (e.g., active listening, constructive feedback to colleagues) ○ Teacher coaching ○ Professional learning communities				
3. This summer's STEM Academy provided me with the tools I need to apply in my classroom or school the principles of: ○ Project-based learning ○ Maker-based instruction ○ Social and emotional learning ○ 5E lesson design ○ The scientific process standards ○ Science content knowledge ○ Community-based STEM education resources ○ Learning environment design ○ STEM integration ○ Effective communication (e.g., active listening, constructive feedback to colleagues) ○ Teacher coaching ○ Professional learning communities				

4. **The content of this summer's STEM Academy met my expectations.**
5. **The summer academy content build on the previous year's content.**
6. **The knowledge I gained at this summer's STEM Academy will help me improve my science instruction.**
7. **The knowledge I gained at this summer's STEM Academy will help me improve other teachers' instruction.**
8. **The structure of this summer's STEM Academy enhanced my understanding of the science content I teach.**
9. **This summer's STEM Academy was interactive.**
10. **The follow-up coaching and support planned for the school year will help me apply the following concepts <u>in my science instruction</u>:**
    - **Project-based learning**
    - **Maker-based instruction**
    - **Social and emotional learning**
    - **5E lesson design**
    - **The scientific process standards**
    - **Science content knowledge**
    - **Community-based STEM education resources**
    - **Learning environment design**
    - **STEM integration**
11. **The follow-up coaching and professional learning communities planned for the school year will help me apply the following concepts <u>within my science department</u>:**
    - **Effective communication (e.g., active listening, constructive feedback to colleagues)**
    - **Teacher coaching**
    - **Professional learning communities**

12. **Speakers at this summer's STEM Academy workshops delivered high-quality information about:**
    - **Project-based learning**
    - **Maker-based instruction**
    - **Social and emotional learning**
    - **5E lesson design**
    - **The scientific process standards**
    - **Science content knowledge**
    - **Community-based STEM education resources**
    - **Learning environment design**
    - **STEM integration**
    - **Effective communication (e.g., active listening, constructive feedback to colleagues)**
    - **Teacher coaching**
    - **Professional learning communities**

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?