IMPACT OF EVIDENCE-BASED TEACHING PRACTICES ON SVSM NANOSCALE SCIENCE COURSE AND TRANSFORMING STEM TEACHING AND LEARNING ACADEMY

by

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ABSTRACT

JENNIFER KANT. Impact of Evidence-Based Teaching Practices on SVSM Nanoscale Science Course and Transforming STEM Teaching and Learning Academy. (Under the direction of DR. DAVID PUGALEE and DR. JORDAN)

Quality STEM education in secondary and post-secondary schools is vital to the advancement of knowledge and technology for the United States. Quality STEM education is found where evidence-based teaching practices are implemented in the classroom. This dissertation focuses on two programs and their impact on participants with the goal of providing quality STEM education. The STEM Academy is a faculty learning community with the goal to support faculty members in implementing new evidence-based teaching practices at UNC Charlotte. The second program is Summer Ventures in Science and Mathematics (SVSM) Nanoscale Science course for high school students in North Carolina. The data for investigating the experiences of the participants in the STEM Academy was collected through semi-structured individual interviews as well as focus groups. The transcripts of these were thematically coded to find consensus on the benefits of the STEM Academy and the barriers to implementing new evidence-based teaching practices. The data for investigating the impact of the SVSM Nanoscale Science course and its revisions was collected through the scoring of student final papers using a rubric specific to the Big Ideas in Nanoscale Science (BINS) and the experimental design process. Also, the Nanoscale students were given the Student Attitudes towards STEM (S-STEM) survey at the beginning and end of the course. The results of the STEM Academy interviews and focus groups yielded 11 themes; six describing benefits and five describing barriers identified by the participants. These results can help to reform and grow the STEM Academy for future participants to meet its goals of supporting faculty members in implementing evidence-based teaching practices in STEM classrooms at UNC Charlotte. The results of scoring the student final papers from the SVSM Nanoscale Science course showed significant improvements to writing research questions, designing experiments, and writing conclusions about their findings for students in the second cohort compared to the first cohort. These findings indicate the revisions to the course had a positive impact on student outcomes. The S-STEM survey results show the students maintained or slightly improved their positive attitudes towards STEM after participating in the SVSM course.

Key words: Nanoscale Science, Evidence-Based Teaching Practices, Faculty Learning Community

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DEDICATION

This dissertation is dedicated to my parents, Esther and Steven Kant, for their constant support, enthusiasm, and encouragement. And it is dedicated to my husband, Kevin Vopelak, for his support and love despite not understanding why I would ever want to do all of this.

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LIST OF ABBREVIATIONS

ALA	Active Learning Academy
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
BINS	Big Ideas in Nanoscale Science
C1, C2, C3	Cohort 1, Cohort 2, Cohort 3
DBR	Design-Based Research
FLC	Faculty Learning Community
GST	General Systems Theory
ID	Instructional Design
IRB	Instructional Review Board
NCDPI	North Carolina Department of Public Instruction
NNI	National Nanotechnology Initiative
PBL	Project-Based Learning
PLC	Professional Learning Community
SCL	Student Centered Learning
S-STEM	Student Attitudes towards STEM survey
STEM	Science, Technology, Engineering, and Mathematics
STEM Academy	Transforming STEM Teaching and Learning Academy
SVSM	Summer Ventures in Science and Mathematics
TA	Teaching Assistant
UNC Charlotte	University of North Carolina at Charlotte

INTRODUCTION

The success of university students in science, technology, engineering and mathematics (STEM) courses is essential to preparing them for their future as leaders and innovators in the fields that shape our world. Student success is a hard-won endeavor, and active learning (a student centered approach that has students actively involved in their own learning) and other evidence-based teaching strategies are established approaches in STEM pedagogy that ensure student learning and comprehension (Abdi, 2014). Instructors in higher education are often not coached in pedagogical practices that can be helpful to the success of their students. At UNC Charlotte, the Transforming STEM Teaching and Learning Academy (STEM Academy) is a professional development program initiated by the Office of Undergraduate Education to support STEM instructors in implementing evidence-based teaching strategies to improve student outcomes. The STEM Academy has already brought 60 professors from approximately ten different disciplines together in a Faculty Learning Community (FLC). Similar active learning teaching strategies are also being utilized in the Summer Ventures in the Science and Mathematics (SVSM) program which brings exceptional high school students from across the state of North Carolina together for a four week intensive course in STEM content and research methods on the University of North Carolina at Charlotte (UNC Charlotte) campus. A curriculum with a focus on Nanoscale Science has been designed and implemented to showcase the innovative and interdisciplinary research taking place in the Nanoscale Science program, and to inform students about the many opportunities available to them in STEM fields.

The aims outlined below utilize the collection of both qualitative as well as some quantitative data to analyze and assess the two programs. My background in Chemistry and Physics for Secondary Education and experience as a classroom teacher, as well as my coursework in the Nanoscale Science Ph.D. program provided me with the necessary insight and knowledge to complete these aims. My future goals in continuing my career in academia will be aided in analyzing the adoption and implementation of evidence-based pedagogical techniques in varied classroom settings.

Aim 1 – Assessment of Active Learning Strategies Implemented from STEM Academy Participants: Instructors who have participated in the STEM Academy were interviewed and participated in focus groups to ascertain if and how they have implemented the pedagogical strategies developed in STEM Academy.

Aim 2 – Development and Assessment of the Curriculum for SVSM Nanoscale Science Course: Curriculum was developed for the SVSM Nanoscale Science course and the instruction was based on student-centered pedagogical strategies. The curriculum and instructional design was evaluated and revised based on the evaluation of student final papers.

Aim 3 – Assessment of SVSM Nanoscale Science Participant Attitudes towards STEM: Students who participated in the SVSM Nanoscale Science program took a survey at the beginning and end of the course to evaluate their attitudes towards STEM. These results were analyzed using a two-way ANOVA test to understand the SVSM Nanoscale Science course impact on student attitudes towards STEM.

The goal of these aims has two main points of focus: the STEM Academy and the SVSM Nanoscale Science course. Both of these programs prioritize the incorporation of student-centered, active learning approaches to teaching. The STEM Academy was created in congruence with the Office of Undergraduate Education’s goal of improving student outcomes in introductory STEM courses at UNC Charlotte. The STEM Academy program was designed and led by Kathryn Asala, PhD. Chemistry, and Tonya Bates, M.S. Biological Sciences. The STEM Academy is a faculty-led learning community that aims to introduce STEM instructors to evidence-based best practices. The purpose of my research on the STEM Academy is to understand its influence on teaching practices by collecting narrative data from participants through individual interviews and focus groups. The STEM Academy had not yet been assessed for its effectiveness in reaching its goals. These goals are to introduce STEM faculty to the latest research on cognitive science, a variety of pedagogical techniques that have been successfully used in STEM classrooms, and support them as they adopt evidence-based best practices.

Along with the assessment of a pre-existing program for higher education faculty, I have also taken the evidence-based teaching strategies of active learning and student-centered learning to develop a design-based course to introduce high school students from across North Carolina to Nanoscale Science and the conduction of scientific research. With assistance from Alex Rolband, Yizhou Wang, and Kanika Dhiman, a curriculum was developed for a novel course on Nanoscale Science for students in SVSM. We have expertise in this topic from our completion of course work in the Nanoscale Science PhD program at UNC Charlotte. The course focuses on the interdisciplinary nature of Nanoscale Science through the use of active learning techniques. The course content covers the major concepts of Nanoscale Science such as structure of matter, forces and interactions, quantum effects, size-dependent properties, and self-assembly. Students experience hands-on lab activities as well as characterization tool demonstrations while being guided through the completion of their own research project. Each student completes an individual or pair research project during the SVSM course. These research projects result in a paper, poster, and presentation on the student-designed and conducted experiment. The purpose of this design-based research study is to assess the student products for evidence of understanding of Nanoscale Science concepts as well as proper design of experiments. The final papers from the two cohorts were compared to understand the impact of the changes made during course revision between iteration 1 and iteration 2. Students were administered the Student Attitudes towards STEM (S-STEM) survey at the beginning and end of the course, and this data was compared to analyze how the course has influenced student attitudes and interest in STEM fields. The results of the data from student products and S-STEM were used when revising the curriculum and instructional design of the course after its first iteration. The results from the second iteration will be used in revising the course for future cohorts.

LITERATURE REVIEW

Addressing major world problems is often dependent on the hard work and innovation of the world's scientists, engineers, and educators. Without new minds entering these fields, progress cannot continue. Ensuring STEM education in our nation's colleges and universities is as effective as possible is imperative to building a solid foundation for students heading into this brighter future.

The State of STEM Education in the United States

"In 2019–20, STEM fields made up 8 percent of associate's degrees, 21 percent of bachelor's degrees, 17 percent of master's degrees, and 16 percent of doctor's degrees" (Irwin et al., 2022, p.27). Attrition rates for STEM majors are high (Tharayil et al., 2018) despite calls for the reform of STEM education that have been put forth since the early 1980s (Michael, 2006). Many strategies have been suggested to lower attrition rates and better prepare students entering STEM fields. The strategies explored in this study include increasing the use of evidence-based pedagogical practices in college STEM courses and developing programs that introduce students to advanced STEM material early in their academic careers in order to foster enthusiasm for the subject area. I will be exploring the current state of STEM education in the United States as well as the types of evidence-based practices that have been shown to better teach and motivate students.

According to the National Center for Education Statistics (NCES), 48% of American students in bachelor programs who began STEM programs between 2003 and 2009 left those programs, 28% switched to non-STEM degrees, and 20% left higher education altogether (Chen, 2013). Also, while just as likely to enter STEM programs as their white peers, Black and Latino students are more likely to switch to non-STEM majors (Riegle-Crumb, King & Irizarry, 2019). As colleges and universities struggle to foster STEM majors' progress through programs to graduation, new students entering higher education are more poorly prepared than ever before. ACT scores for the College Readiness Benchmark for the graduating class of 2022 show the continuation of a five-year decline for American students (ACT, 2022). The percentage of students meeting the STEM Benchmark in 2018 was 20%, but by 2022 that percentage had fallen to 16% (ACT, 2022). Science Benchmark percentages have fallen from 36% in 2018 to 32% in 2022 while Math Benchmark percentages have declined from 40% in 2018 to 31% in 2022 (ACT, 2022). While some of this decline may be attributed to the COVID 19 pandemic impacting educational practices and access during the time period these exams were administered, these scores were not promising even at their higher ranges. According to the US Bureau of Labor Statistics, 62.0% of 2022 high school graduates are enrolled in colleges or universities (U.S. Bureau of Labor Statistics, 2023). While the results of the ACT exam show that most students are not prepared for college-level work, the majority of these students are still enrolling in college classes. Now more than ever, students entering STEM programs will need access to effective teaching practices in their college classes in order to close this achievement gap.

College professors are not typically given formal instruction in pedagogy before they are tasked with instructing students (Fertig, 2012). While professors, especially those in STEM fields, have plenty of expertise in their subjects and experience with research in their fields, they do not necessarily have any expertise or experiences with teaching students. "The unstated assumption is that if you have a degree in a subject, you must know how to teach it at the college level" (Felder, 2016, p.1). This leads most professors to rely on more traditional, lecture-based teaching (Mastascusa, Snyder, Hoyt, & Weimer, 2011). It is what is most common in college courses, and it is often how professors were taught when they were taking their undergraduate classes. While universities have made efforts to increase instructors' awareness of more effective teaching practices, there is not much evidence to show that participants in professional development workshops go on to implement these practices in their classrooms (Ko, Wallhead, & Ward, 2006). This is particularly true for those instructors who are teaching large size classes (Jaschik, 2018).

Effective teaching is essential to improving STEM program retention rates. "A single course with poorly designed instruction or curriculum can stop a student who was considering a science or engineering major in her tracks" (Kober, 2015, p.xi). University faculty members often have packed schedules with teaching, research, advising, and committee responsibilities, which means leaving little time for regular pedagogical professional development. Therefore, professional development programs need to be as effective as possible. Collaboration between faculty in professional learning communities (PLC) can lead to better student outcomes (Stoll, Bolam, McMahon, Wallace, & Thomas, 2006) and can make professional development more effective (Prenger, Poortman, & Handelzalts, 2019). Curriculum design is more effective when completed by a team as it allows for influences from different sources of subject matter and pedagogical expertise (Mohanasundaram, 2018). This knowledge influenced the design of the STEM Academy at UNC Charlotte.

Evidence-Based Teaching Practices

One of the major pedagogical practices introduced and encouraged by the STEM Academy program is active learning. Active learning has been described as ''instructional activities involving students in doing things and thinking about what they are doing'' (Bonwell

& Eison, 1991, p.2). The definition of active learning has been expanded to include three primary components: (1) Students receiving information via readings, direct instruction, etc., (2) Activities or experiences that involve either direct student participation or student observation of a concept, and (3) Student reflection on their knowledge and the activity to reach a consensus about the topic (Fink, 2005; McConell et al., 2017). Active learning has been shown to increase higher order thinking in students (Freeman et al., 2014). Higher order thinking is based on Bloom's taxonomy, which categorizes educational goals into a hierarchy framework (Armstrong, 2010). Higher order thinking is defined as students moving into metacognitive thinking which requires using knowledge to analyze, evaluate, and create (Armstrong, 2010). When students are actively involved in their own learning process, it keeps students engaged and yields better retention and cognition of the concepts (Fink, 2005; Freeman et al., 2014). Gifted students, like those who participate in SVSM courses, have shown improvement in their 21st Century learning abilities when taught using inquiry-based STEM activities (Abdurrahman, Nurulsari, Maulina, & Ariyani, 2019).

Student-Centered Learning (sometimes referred to as learner-centered) is an instructional approach in which students influence the activities, materials, and pace of learning in a classroom (Collins & O'Brien, 2003). Student-Centered Learning (SCL) involves the implementation of active learning and Problem-Based Learning (PBL) instead of traditional lecture approaches. This puts students at the center of the design of the class activities to help increase learner motivation and promote higher order thinking of the material (Collins & O'Brien, 2003). When adapting SCL into curriculum design, a focus on building community, sharing power, and assessment can be used to guide the implementation (Cullen, Harris, Hill, & Weimer, 2012). Building community in an SCL environment is essential because students are being asked to learn from each other. Students are also being asked to share power with their instructor by influencing the activities, content, and pacing of the class. The assessment of student learning needs to be ongoing to evaluate if students are meeting course objectives.

While evidence-based teaching practices have their clear benefits to students, implementation of these practices is a large order for many instructors. Some of the common barriers to implementing evidence-based teaching practices are limited class time, an increase in preparation time, the challenge of adapting the practices to large class sizes, and a lack of needed materials, equipment, or resources readily available in a post-secondary setting (Bonwell & Eison, 1991). Instructors also take on risks when implementing these practices. These risks could take the form of student resistance to participation, criticism from students and colleagues, and the inability to cover all required content (Bonwell & Eison, 1991). These barriers align with the barriers identified by the STEM Academy participants in their interviews and focus groups. When investigating what is required for instructors to be prepared to implement these new practices, three key elements are identified: being motivated (having a positive attitude towards the idea of the practices and support to follow through), being able (having the resources and coaching required to know how to implement the practices), and having opportunities to try and practice the new techniques (Diery, Knogler, & Seidel, 2021). These elements will be needed for a successful faculty learning community focused on implementing evidence-based teaching practices.

Faculty Learning Communities

A faculty learning community (FLC) is a collaborative group of teachers who participate in group discourse, reflection, and goal setting to work towards improving their own teaching and that of their colleagues (Ward & Selvester, 2012). There are cohort-based FLCs and subject-based FLCs, in which the former is based around connecting a particular group of faculty, while the latter is based around connecting faculty around a particular problem or topic that needs to be addressed (Cox, 2004). The STEM Academy is a cohort-based FLC in that the curriculum is shaped by the participants who are all part of an important group of faculty (those who teach foundational or core courses in STEM majors). The attributes of a high-quality FLC are listed below as constructed by Milton Cox in his article, "Introduction to Faculty Learning Communities" (2004, pg. 9):

- meet for a period of at least six months
- have a voluntary membership
- meet at a designated time and in an environment conductive to learning
- offer group contributions to individual projects in a timely manner
- foster empathy for each other and develop their own culture
- operate by consensus rather than majority
- engage in complex problems
- energize and empower participants
- have potential to transform institutions into learning organizations
- use a holistic approach and not overly formal discussion nature
- focus on building community
- focus on the ultimate beneficiaries of the program – the students

High-quality FLCs also utilize the Kolb experiential learning cycle, or a similar learning cycle. The Kolb experiential learning cycle consists of four stages; concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb & Kolb, 2018). Experiential learning is different than didactic learning (traditional methods of learning based on textbooks, lectures, and homework assignments) in that it allows learners to apply knowledge to real-life situations and experiences. Experiential learning encourages active participation, creative problem solving, and critical thinking while building communication skills (Main, 2022).

To evaluate the impact of FLCs, an ideal model would be to measure the difference in student learning as a result of the instructor participation in the FLC. However, this has been deemed impractical due to the inability to create an instrument to measure student learning in a valid and reliable way that can accurately attribute the outcomes to participation in the FLC when there are so many confounding variables (Sirum & Madigan, 2010). When looking at how instructional development programs and workshops are assessed, there are five levels that can be measured; participation, satisfaction, learning, application, and impact on student learning (Connolly & Millar, 2006). These levels are in increasing order of significance to understanding the impact of a program as well as the difficulty of collecting convincing evidence. Information on (1) who participated, (2) if they were satisfied with the experience, (3) what they learned from the experience, and (4) if they have applied what they learned in their teaching practice are all categories of data that are being collected through individual interviews and the focus group for the STEM Academy.

Some common methods for collecting data on the impact of FLCs are surveys (Glowacki-Dudka & Brown, 2007; Richlin & Cox, 2004), open-ended questionnaires, and observing evidence of professional growth of participants through showcasing their work through professional presentations at conferences or publications (Ward & Selvster, 2012). Surveys are most commonly used due to the ease in which many people can be assessed in a uniform, efficient, and inexpensive approach. Surveys are most useful when the sample size is relatively large to create a consensus. When working with smaller sample sizes, open-ended questionnaires allow for more robust data collection with opportunities for subjects to delve deeper into their thoughts and feelings about their experience with the program (Mertens, 2015).

Qualitative Research and Trustworthiness Criteria

Alkin and Vo (2018) explain, "The main distinguishing characteristic between research and evaluation is that the former seeks conclusions and the latter leads to decisions" (p.9). These findings or conclusions seek to be applicable across settings and to like programs, while evaluation is used to only apply to the particular setting and program to which it is being applied (Alkin & Vo, 2018). There is much debate about the distinctions between research and evaluation, and there is often overlap in their methods and evaluators often enter their profession through their work as researchers (Mathison, 2008). Aim 1 of the proposal looks to understand common benefits and barriers of implementation of evidence-based teaching practices developed through the STEM Academy so that not only can our FLC be improved, but these results can be shared with the academic community to offer insight in how to develop and execute an effective FLC. The findings, while based on a case study, will be generalizable to those researching how to transform their institutions through improved pedagogical practices. The findings add to the existing literature that confirms common themes of benefits and barriers to FLC and implementation of evidence-based teaching practices. Understanding these common themes is useful to other institutions which aim to implement similar FLCs so they can anticipate barriers that will need to be addressed.

Case study research is an approach used to thoroughly describe complex phenomena of a program in ways to discover new and deeper understandings of these phenomena (Mertens, 2015). Research design of a case study consists of (1) developing research questions – typically consisting of "how" and "why" questions, (2) identifying any hypotheses, while not all case studies lend themselves to hypothesis statements due to their exploratory nature, (3) specifying the unit of analysis – i.e. the program, (4) establish the logic linking the data to the hypotheses – data often consists of observations, interviews, document reviews, and artifacts, and lastly (5) the criteria for interpretation of the findings should be explained – no statistical tests are usually appropriate for case study findings, so researchers identify different patterns that are sufficiently distinguishable from rival hypotheses (Yin, 2009). Case studies use a triangulated research strategy to confirm validity of the data analysis. Four types of triangulation have been identified in the literature, with two being relevant to the assessment of the STEM Academy. Theory triangulation utilizes the interpretation of the same results by investigators with different viewpoints, and methodological triangulation increases the confidence in the interpretation of the results by using one approach followed by a different approach (Tellis, 1997). The data from the interviews as well as the focus groups was interpreted by me, as well as the co-investigators Dr. Kathy Asala and Tonya Bates, which will satisfy theory triangulation of the data. The methodological triangulation will be satisfied by the use of both individual interviews and focus groups protocols for data collection on the same research questions.

Research is divided into two main categories of methodology; quantitative which relies on quantifiable measurement, and qualitative which relies on description. The aim of qualitative research is to analyze the words of the subjects and observations of the researcher to understand their meaning, look for patterns, and construct a reality (Adler, 2022). Due to the narrative nature of qualitative research, the goal of validity of the findings cannot be reached like it is in quantitative research. Instead qualitative researchers must strive to achieve trustworthiness in the realities they construct through the dissemination of their findings (Stahl & King, 2020). Lincoln and Guba (1985) establish four general criteria for building trustworthiness in qualitative research. These criteria are credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985).

As Stahl and King (2020) explain, trustworthiness through credibility seeks to show how congruent the findings are with objective reality. In other words, do these findings make sense with the reality we all experience? This can be challenging due to the subjective nature of human experience and the different theoretical orientations used to understand qualitative findings. What has been established by researchers is the use of triangulation in analysis. Approaching analysis from multiple angles, be it in more than one type of data (data triangulation), multiple researchers (investigator triangulation), multiple theoretical orientations (theoretical triangulation), or more than one setting or context (environmental triangulation), any of these can create trustworthiness through credibility in qualitative research (Tellis, 1997). Trustworthiness through transferability seeks to establish a similar effect to quantitative research's replicability. Case study methodology cannot have replicability due to the nature of its process, but the lessons learned from the analysis of its findings should be able to be transferred to similar situations based on the trustworthiness of the research. This transferability can be built on the use of thick description in careful reporting of the data collection process. This allows for readers of the research to understand the full extent of the circumstances to make judgements on how the findings can be applicable to new contexts beyond the original case (Stahl & King, 2020). Trustworthiness through dependability can be established through the peer review process of analysis and later publication. If more than one researcher reaches the same conclusions about the same data set, it lessens the likelihood that individual bias has greatly impacted the findings. Trustworthiness through confirmability can also be created through the peer review process, as well as practices which aim to ensure the researchers themselves create as little disruption to the environment they are studying as possible. These precautions aim to maintain the objective reality being studied and to minimize contamination (Stahl & King, 2020).

In qualitative research, the researcher acts as the principal research instrument, so the trustworthiness of the findings is a direct extension of the trustworthiness of the researcher (Dodgson, 2019). Being clear and detailed about the theoretical perspective of the approach to the analysis, the member checks and triangulation methods, as well as the reflective analysis from researcher through the use of bracketing builds the case for trustworthiness in qualitative research (Adler, 2022).

In investigating the impact of the STEM Academy, I am utilizing both individual interviews as well as focus groups to collect qualitative data on the experiences, thoughts, and feelings of faculty participants. The individual interviews are semi-structured utilizing a script with open ended questions to allow subjects to express their thoughts, while creating data sets that can be compared across interviews to find patterns for thematic coding (Mertens, 2015). The focus groups have a similar question format to the interviews, so the data collected from both protocols can be combined under the same thematic codes for analysis. As discussed above, using triangulation in a case study methodology gives trustworthiness through credibility to qualitative data analysis. Within the protocols for both the interviews and the focus group, anonymity is ensured and maintained for the subjects to allow them to feel comfortable to be open and honest about their experiences in the STEM Academy and as faculty at UNC Charlotte. Anonymity can help in establishing confirmability to the findings because it aims to remove complicated power dynamics from the environment to obtain information about the objective reality.

Rubric Design

As part of the curriculum design process, assessing the effectiveness of instruction is essential to continue the cycle of improvement. In order to collect data on student outcomes, a rubric was developed to assess the final student research projects in areas of content knowledge and research skills. Rubrics have been shown to be useful in identifying the need for improvements in courses and programs in higher education (Reddy & Andrade, 2010). A good rubric addresses the most important aspects of student performance (in the case of Aim 2, Nanoscale Science content knowledge and research design skills), has measurable student outcomes, is easy for both the student and the assessor to understand, and has a clear progression between levels along categories (Stix, 1996). The trustworthiness and rigor of a rubric comes from testing the instrument as well as triangulation of the data collection. For Aim 2, each of the student final papers was assessed using the rubric by three different instructors in order to increase the reliability of the data. These instructors worked independently when giving their initial scoring of the final papers to avoid influence from the other evaluators.

The instrument used in Aim 3, the Student Attitudes towards STEM survey, has been tested for reliability and rigor by its development team. The S-STEM survey was developed by The Friday Institute for Educational Innovation at North Carolina State University in 2013 (Faber, Unfried, Wiebe, Corn, & Townsend, 2013). The survey went through pilot testing and factor analysis and the revised survey was tested on 9,000 middle and high school students (Faber et al., 2013). Adherence to the standards established in qualitative research ensures the trustworthiness for the data collection and analysis for Aims 1 and 2 of this dissertation.

The Case for Teaching Nanoscale Science to High School Students

Nanoscale Science covers a large body of research focused on the study of the phenomenon that occurs at the nanometer scale of matter. In recent decades, researchers have developed techniques for manipulating single atoms or small groups of atoms and characterizing the properties of these materials (Stupp et al., 2002). Nanoscale Science is interdisciplinary and can include research in areas including Chemistry, Physics, Medicine, Computer Science, Material Science, Biology, and Bioinformatics. Nanoscale Science is fundamental to the progress of technology, and the Department of Energy Office of Science's Office of Basic Energy Sciences established five Nanoscale Science Research Centers to support and continue research endeavors (Office of Science, 2024). Nanoscale Science research has been a priority of the National Science Foundation (NSF) for nearly two decades (National Science Foundation, 2006).

The US Department of Education prioritizes the enhancement of Science, Technology, Engineering, and Mathematics education for students across all grade levels (U.S. Department of Education, 2022). These initiatives are also supported by the National Nanotechnology Initiative (NNI) and the NSF through their initiatives, recommendations, and funding goals in recent years (National Nanotechnology Initiative, 2023; National Science Foundation, 2006). The most recent evaluation of NNI recommends enhancing experiential learning programs for nanotechnology students to create the collaborative, multi-disciplinary workforce needed for nanotechnology (Arnold, Prabhakar, & Zuber, 2023).

Incorporating nanotechnology keeps science classes relevant to students which improves student motivation and interest in continuing study in higher education (Blonder & Sakhnini, 2017). Students develop positive views on nanotechnology and they see how it influences their lives and their futures. Science curriculum should be updated to include emerging scientific theories and innovation to stay current and relevant to students (Murcia, 2013). High school students can learn the concepts of Nanoscale Science, but it takes careful scaffolding of foundational knowledge and the use of hands-on activities (Schank, Wise, Stanford, & Rosenquist, 2009). While students enjoy the material, especially with demonstrations and relations to emerging technology, teachers often feel ill prepared due to lack of professional development and experience with the material (Ha & Lajium, 2022).

Other educators have developed programs and instructional tools and activities to incorporate Nanoscale Science into their curriculum at the high school level. Some programs focus on a particular demonstration or example to relate broader Nanoscale Science concepts to students. One such example focuses on building solar cells to teach students about photon behavior and energy transfer at the nano level (Eliyawati, Sunarya, & Mudzakir, 2017), while another uses graphene as a central focus to educate students on allotropes of carbon and how the properties of a substance can change based on its bonding orientation (Guasch, González, & Cortiñas, 2020). Some instructors use a one-day, fun activity like making ice cream using liquid nitrogen to explore how bulk properties change from changes at the Nanoscale (Jones, Krebs, & Banks, 2011), while other researchers are developing entire e-learning curriculums to teach about Nanoscale Science (Yueh, Chen, Lin, & Sheen, 2014). Efforts are being made to support teachers on how to incorporate Nanoscale Science into their classrooms (Blonder & Mamlok-Naaman, 2016), and extracurricular programs are being implemented to provide opportunities for students to learn these concepts (Burgin & Sadler, 2013). The approach for the SVSM course focused on the development and conduction of a four week summer course that teaches high school students about Nanoscale Science and guides them through individual research projects.

This course was developed with focus on evidence-based practices for the instructional design and curriculum based on students' previous knowledge.

Instructional Design and Curriculum Development of a New Science Course

Instructional design (ID) is a planning process that aims to create a logical and complex system within which to build curriculum materials (Richey, Klein, & Tracey, 2011). ID is compiled of several theoretical frameworks including general systems theory (GST) which views our environment as a series of concepts and orientations that are used by many disciplines to show the relationships between various parts of the empirical world. GST is interdisciplinary in nature and relies upon the idea that studying concepts in a vacuum is not ideal in understanding their true nature and influence on the broader world and its systems (Richey et al., 2011). This theory influences the approach in writing curriculum for an interdisciplinary course on Nanoscale Science.

In examining the process of teaching, one must take into account how students learn. Postmodernism has influenced how we view learning as a communal process based on experiences (Cullen et al., 2012). Therefore, lessons need to be planned to create meaningful experiences for the students while maintaining rigor and covering the required content (McConnell, Conrad, Brooks, & Uhrmacher, 2020). Specific approaches to lesson planning allow for focusing on different primary goals such as skill development, sensory-rich experiences, real-world connection, and relationship building (McConnell et al., 2020). When designing curriculum, certain standards are followed to maintain effectiveness and usability. Curriculum standards include: educational objectives, curriculum structure, content, teaching and assessment protocols, curriculum management, roles and responsibilities, and evaluation of curriculum effectiveness (Grant, 2018). The curriculum design process uses current learning theories on how students gain knowledge and skills, the learning outcomes that need to be achieved by students in the course, and evidence-based teaching strategies to design a plan for the instructor of the course to execute (Laurillard, 2010). The curriculum design process is ongoing in that student data (i.e. test scores) and artifacts (i.e. projects, papers, homework assignments) that show outcomes are being collected and analyzed to revise and improve the curriculum design. “An important feature of the approach to teaching and learning … is that assessment is integrated into the teaching and learning activities as well as being used at the end of the learning sequence to indicate the extent to which the material has been mastered” (Laurillard, 2010, p.5).

Curriculum or instructional design has often utilized a bottom-up approach where instruction is created for individual pieces of content, rather than starting from the broader learning goals of the course and then planning instruction for a top-down view (Reigeluth & An, 2020). Students learn better when their mind is prepared to take in details based on a larger idea or concept (McGuire, 2015). These concepts influenced both the professional development curriculum of the STEM Academy as well as the curriculum of the SVSM Nanoscale Science course. The STEM Academy emphasizes planning curriculum with the larger learning goals in mind to create courses that are more effective. Taking into account theories of learning and instructional design, the design of curriculum utilizing SCL and active learning strategies should yield better student results that show a deeper understanding of content and utilization of higher order thinking. The SVSM Nanoscale Science course was designed with a bottom-up approach starting from the major concepts of Nanoscale Science as outlined in “The Big Ideas of Nanoscale Science and Engineering: A Guidebook for Secondary Teachers”, and the lessons and activities were planned to help students explore those concepts (Stevens, Sutherland, & Krajcik, 2009).

Once the curriculum for a course is designed, it can be assessed using design-based research (DBR) which is "the systematic study of the design, development, and evaluation of educational interventions such as programs, strategies and teaching-learning materials, products, and systems" (Cárcamo, Fuentealba, & Garzón, 2019, p.3). DBR is useful when attempting to answer or evaluate complex problems in educational practice, such as the effectiveness of implementation of a new course curriculum (Reimann, 2011). The goal of DBR is to support the learning process and continually improve the design by testing and revising the curriculum.

Statistical Analysis

To analyze the results of scoring the student final papers for the SVSM Nanoscale Science course using the designed rubric, one needs to compare two independent groups with one dependent variable. Usually a t-test would be useful in a statistical situation as described, but the data is not normally distributed and has a very small sample size. Therefore, it is more appropriate to use a Mann-Whitney U test to analyze the data (Laerd Statistics, 2024a).

To analyze the results of the pre-post data from the Student Attitudes towards STEM survey (S-STEM) with two cohorts, I used a two-way analysis of variance (ANOVA) model. In a comparison study, analysis of covariance (ANCOVA) modeling of either change score or post-treatment score as the outcome has proven to be the most effective in terms of examining treatment effect (O'Connell et al., 2017). However, this was in cases of a randomized, clinical study. The subjects from Aim 3 are not randomized, and therefore an ANOVA model is more appropriate. The treatment is participation in the Nanoscale Science course through SVSM. The effect would be a change in the post-treatment responses on the S-STEM. A two-way ANOVA test is used when one wants to understand the interaction between two independent variables on a dependent variable (Laerd Statistics, 2024b). In this study, the two independent variables are the groups which are the two cohorts from the two different iterations of the course, and the intervention (participating in the SVSM Nanoscale Science course). The dependent variable is the S-STEM survey ratings. I want to know if there is an interaction between the cohorts and the intervention on their attitudes towards STEM. A two-way ANOVA test analyzes the relationship between the main effect of intervention (comparing the mean results of pre- and post-surveys of all participants), the main effect of group (comparing the mean results of two cohorts for all surveys), and the interaction between intervention and group (intervention X cohort).

Discerning between correlation and causation can be challenging in even the most robust of quantitative studies. A strong correlation may not be indicative of causality due to random chance (variables appear to be related, but the trend is due to random chance from the data which is more likely in studies with small sample sizes like this one) or there is a third, unstudied variable that is causing the relationship to appear stronger between the variables studied (JMP Statistical Discovery, 2023). Randomization is usually a key component to the experimental design process in order to prove a causal relationship. Due to the nature of this study, randomization is not possible because the treatment (participation in the course) is going to be applied to all subjects. The participants apply (motivation) and are selected based on their applications, rated by two readers. The nature of this study in which the treatment is being applied to the subjects which are isolated in the treatment plan (the students are taking an intensive four week course in which they travel to and stay on campus together for the ending three weeks) it is reasonable to say that any difference in the pre and post S-STEM results are caused by the participation in the course. However, all results from the S-STEM cannot necessarily be attributed to the course design of the Nanoscale Science course. The subjects have other shared and individual experiences during their time in SVSM that are outside the structured course time. Causality may not be able to be shown for the results of the statistical analysis of the S-STEM data.

This literature review has established the problems this research aims to explore, and has established the validity of the analytic choices made to investigate the research questions. Following are the methodology and results of the investigation of the three aims of this dissertation.

AIM 1: STEM ACADEMY

Instructors who have participated in the STEM Academy were interviewed and participated in two focus groups to ascertain if and how they have implemented the pedagogical strategies explored in the STEM Academy.

Sixty instructors from ten different STEM disciplines have participated in the Transforming STEM Teaching and Learning Academy over its first two cohorts at UNC Charlotte. The Office of Undergraduate Education initiated its development in order to improve student results and lower attrition rates in introductory STEM courses. The professional development activities for the STEM Academy has used many resources, with a particular focus on “Teaching and Learning STEM: A Practical Guide” by Felder and Brent (2016). Most initiatives to implement inquiry-based learning practices in undergraduate STEM courses focus on a single subject or class (Adair, Jaeger, & Price, 2018; Downs & Wilson, 2015; Muller, Shacham, & Herscovitz, 2018; Pinto, Nicola, Mendonça, & Velichová, 2019; Requies, Agirre, Barrio, & Graells, 2018; Sujarittham, Tanamatayarat, & Kittiravechote, 2019). The STEM Academy is novel in its interdisciplinary approach. The STEM Academy has included instructors from the following disciplines: Chemistry, Biology, Physics, Mechanical Engineering, Mathematics, Accounting, Kinesiology, Geography, Earth Sciences, and Computing and Informatics throughout its five year execution. The STEM Academy brings diverse instructors together to work closely over the course of an academic year, developing new strategies and helping each other problem-solve as they implement active learning in their classrooms. A learning community allows for collaboration across STEM disciplines and also focuses on the unique challenges of teaching STEM content providing participants with a particularly helpful and fulfilling experience through the STEM Academy.

The STEM Academy has three central goals:

(1) To introduce STEM faculty to the latest research on cognitive science

(2) To expose STEM faculty to a variety of pedagogical techniques that have been successfully used in STEM classrooms

(3) To support faculty as they adopt evidence-based best practices

Now that these instructors have had the time to implement the pedagogical strategies explored at the academy, it is imperative to understand how the participants have utilized the program in their own classrooms and assess if the STEM Academy is reaching its goals, particularly the third goal of supporting faculty in adopting the new practices. While the practices introduced to the faculty in attendance are based on proven pedagogy, it is unclear what impact the STEM Academy has had in changing practices in courses taught by participants. I am using a case study methodology to understand how the STEM Academy has impacted the teaching practices of its participants.

Two approaches were used to collect qualitative data from STEM Academy participants. These approaches were individual interviews as well as focus groups. The research questions being addressed are stated below:

RQ 1: How did the STEM Academy influence teaching practices?

RQ 2: What did faculty identify as the barriers for implementing desired evidence-based teaching practices?

RQ 3: What did faculty identify as the benefits of participating in the STEM Academy?

The questions developed for both the interviews and the focus groups address these research questions that focus on the third goal of the STEM Academy, *to support faculty as they adopt evidence-based best practices.* While the activities and presentations conducted at the STEM Academy meetings show the adherence to the first two goals, the third goal can only be understood by collecting the personal accounts from the participants.

Methodology

In this section I will explain how the individual interviews and focus groups were conducted. I will then explain how the transcripts from both were analyzed and member checked.

Participants

For the interviews and focus groups, there were 19 total participants (n = 19, 11 females and 8 males). The participants were from seven different departments and had teaching experiences ranging from 3 – 29 years. The departments included Mathematics and Statistics (n = 4), Biological Sciences (n = 3), Chemistry (n = 3), Physics (n = 3), Geography and Earth Sciences (n = 3), Computing and Informatics (n = 2), and Mechanical Engineering (n = 1). The participants held a range of employment status at UNC Charlotte. These statuses included Lecturer (n = 6), Senior Lecturer (n = 3), Adjunct Faculty (n = 1), Assistant Teaching Professor (n = 6), Assistant Professor (n = 2), and Professor (n = 1). All participants were full-time employees.

Individual Interviews

An email was sent to faculty members who participated in the Transforming STEM Teaching and Learning Academy asking for voluntary participation in the study. Virtual interviews were scheduled via Zoom lasting approximately 30 minutes. The video recording only captured the interviewer and not the participant. The audio was captured for both the interviewer and interviewee. This was done by "hiding" the participant's video image. There was no plan to contact the faculty following the completion of the interview.

Audio-only interviewees were identified by a pseudonym and the recordings were stored on a password-protected, UNC Charlotte-linked Google Drive and shared with the research team approved by the UNC Charlotte IRB. Recordings were deleted once they were transcribed. Transcriptions were completed within a year of the completion of data collection. An electronic file consisting of the final, de-identified interviews was stored on a password-protected, UNC Charlotte-linked Google Drive and shared with the research team approved by the UNC Charlotte IRB after study completion. Privacy is being protected, and confidentiality is being maintained to the extent possible. Responses were treated as confidential, and all responses were aggregated into an anonymous summary. Interviews are stored with access to this information controlled and limited only to people who have approval to have access according to the IRB. Participation was voluntary. Participants could choose not to take part in the study or could stop at any time.

The interview questions used were:

1. What is your employment status and rank with the University? Part time/Full time and Tenure track, lecturer, part time, etc. Within what department?
2. How many years have you been teaching?
3. How many years have you participated in the academy? (1-3)
4. What courses do you typically teach? What courses are you focused on in the Transforming STEM Academy?

5. What are the benefits you have seen from the academy? Do you feel that the academy provided you with the tools necessary to transition face-to-face classes to online?
6. Can you tell me about an example of an evidence-based practice that you have implemented because of the academy?
   - What was the role of the academy in adopting this practice?
   - How do you like the change? Do you enjoy it?
   - What challenges did you face in implementing this change?
   - Have you implemented this change in upper-level classes?
7. Can you tell me about a second example of an evidence-based practice you have implemented because of the academy?
   - What was the role of the academy in adopting this practice?
   - How do you like the change? Do you enjoy it?
   - What challenges did you face in implementing this change?
   - Have you implemented this change in your non-STEM Academy classes?
8. Did anything deter you from completing or implementing desired practices? How can the Academy help remove these barriers?
9. Has the Transforming STEM Teaching and Learning Academy influenced or led you to change your teaching philosophy? How so?
10. Has the Transforming STEM Teaching and Learning Academy enabled you to coordinate with other faculty within your department as well as outside your department? How so or why not? What are the benefits gained from coordinating with other sections/instructors?

11. Were your efforts to transform your course(s) supported and recognized by your department, college, and university? If so, can you explain how? If not, can you explain what would have made you feel supported and recognized?

These interview questions were developed by Amber Davidson at the instruction of Dr. Coral Wayland from the Office of Undergraduate Education. These questions were chosen to address the research questions and to evaluate the third goal of the STEM Academy as well as to gather information on how the academy's goals integrate into the greater structure of UNC Charlotte. For the STEM Academy's first goal, to introduce STEM faculty to the latest research on cognitive science, interview questions 6, 7, and 9 collect information on what types of practices the participants have implemented as well as the academy's impact on their understanding of teaching and pedagogy. An instructor's teaching philosophy is based on their understanding of how learning occurs, and learning is based in cognitive science (McGuire, 2015). To address the STEM Academy's second goal, to expose STEM faculty to a variety of pedagogical techniques that have been successfully used in STEM classrooms, interview questions 6 and 7 collect information about what particular practices the participants have implemented due to their involvement in the academy. To address the STEM Academy's third goal, to support faculty as they adopt evidence-based best practices, interview questions 5, 8, and 10 collect information on the ability and impact of the STEM Academy's support of the participants. These questions address what kinds of support the participants have experienced, as well as insight into what support is still needed or is lacking when it comes to implementing evidence-based practices from the STEM Academy. Questions 8 and 11 address the impact of the greater structure of the University in its facilitation and support of the faculty participant's implementation of evidence-based practices into their courses. While the STEM Academy works to support the participants, all participants must work within the greater structure of the University and it is necessary to understand how that structure helps or hinders the process of implementing evidence-based teaching practices in STEM courses.

Focus Groups

Two focus groups were conducted to further investigate the research questions. Focus groups are a form of qualitative data collection that is a useful research strategy when trying to understand "how individuals form a schema or perspective of a problem" (Mertens, 2015, p.382). While focus groups are often used in market research, this approach can be useful in instrument review, which is why it is appropriate for evaluating the impact of the STEM Academy as a program. The focus groups were a single-category design as I was only interested in the impact on participants of the STEM Academy and do not plan on questioning faculty who have not participated in the program (Krueger & Casey, 2000). The questions for the focus group listed below were decided based on the preliminary results of the interviews of the participants and a planning session between me and Dr. Elise Demeter. There needed to be fewer questions for the focus group compared to the individual interviews because of the time it takes to allow all the participants to fully address each question. Therefore, the questions for the focus group needed to be more direct to the research questions in order to focus the discussion so it could be easily compared to the data collected from the individual interviews. Below are the questions used for the focus groups.

Opening Questions:

1. Please tell us who you are and which classes you are currently teaching.
2. What motivated you to participate in the STEM Academy?

Transition Question:

3. If you were to walk into a classroom that was using evidence-based teaching practices, what kinds of things would you see and hear?

Key Questions:

4. Describe something you learned from your time in STEM Academy and how you have used it in your teaching practices.
5. What has been one of your biggest frustrations or barriers when implementing new teaching strategies?
6. How would you describe the responses of your peers and administrators outside the STEM Academy to the teaching strategies you are trying?
    a. What kinds of responses contributed to making you feel supported or recognized for implementing good teaching practices?
7. What aspect of the STEM Academy has been the most impactful for your professional development?

Closing question:

8. Is there anything you'd like to mention that we haven't discussed?

Question 4 addresses RQ1 to understand how the STEM Academy has influenced teaching practices of its participants. Questions 5 and 6 address RQ2 to investigate what kinds of barriers faculty faced when implementing the new practices. Questions 6a and 7 address RQ3 to identify the benefits of participating in the STEM Academy. Questions 4 – 7 are focused on the third goal of the STEM Academy. Question 3 is used to get the participants thinking about the pedagogical techniques that were taught in the STEM Academy and gather data on what the participants took away from the activities and presentations used in the STEM Academy sessions. This question addresses the first and second goals of the STEM Academy.

An IRB amendment was written and approved before a recruitment email was sent to past and present participants in the STEM Academy who had not participated in the individual interviews. After approximately one week to allow for responses, the potential participants were sent a poll to find a mutual time to schedule the focus group. The group was split into two focus groups to accommodate the number of faculty wishing to participate and their schedules. The first focus group was conducted on February 21, 2024 with four participants. The second focus group was conducted on March 1, 2024 with five participants. Both focus groups lasted approximately one hour. The audio was recorded during the focus groups and transcribed. Pseudonyms were assigned to each participant for anonymity of the data.

Analysis and Member Check

After the completion of the transcription of the interviews and focus groups, the transcripts were reviewed for thematic coding by me. The transcripts were color coded to reflect the categorization of each statement into its thematic code. These themes were given descriptions and divided into benefits and challenges. The co-investigators for this aim, Dr. Kathy Asala and Tonya Bates, were assigned three individual interviews and one focus group each to read and analyze for thematic coding. The individual interviews were chosen to give a diverse selection of participant genders and department affiliations. They were asked to analyze if the themes found and described by me were accurate and complete using the thematic coding descriptions I provided and the original, non-coded transcripts. Asala and Bates' notes were used to revise the thematic coding of the transcripts and confirm the following results.

Results

A total of 11 themes were identified from the interviews and focus groups. Each of these themes will be described and examples and quotations from the transcripts will be given to communicate the qualitative results of the interviews and focus groups. Full interview and focus group transcripts can be found in Appendix A.

Participants of STEM Academy obtain new resources during meetings and are taught how to implement evidence-based teaching practices

The first theme identified from the interviews and focus groups is Resources and Training. Participants described learning about classroom activities, protocols, strategies, and tools (i.e. online polling or websites) during their time with the STEM Academy. They describe being taught about alternative assessments from traditional exams as well as gaining knowledge and understanding of pedagogical practices and theories. This theme was observed in the comments of 18 out of 19 participants in the interviews and focus groups. For example, in her interview, Mary, a Biological Sciences faculty member, described what she gained from the STEM Academy:

> The primary things that I have seen is that I know where to get information to create different types of activities in my classroom…So knowing where that information is, learning what's out there from my peers, has been so very valuable. And learning about the resources on campus.

Mary also discussed using these new strategies and resources to gather feedback from her students to understand how she is reaching them and improve her assignments based on that feedback.

In Jasmine's interview, as a Physics faculty member, she stated, "In general it broaden up my vision of teaching. It gave me many resources I wasn't aware of. For example from very simple websites to articles on pedagogy, to understanding my problems from a completely different perspective." She went on to describe completing an exercise on rubric development that helped her with utilizing her class time effectively. Georgia, a Biological Sciences faculty member, described what new skills she has acquired and what she had been able to accomplish in revising and improving her courses:

> I've learned to scaffold my course better during course planning for improved outcomes for my students. I've developed my course and my module level learning objectives. And developed traditional and alternative assessments for each objective. And I think I have improved my overall course alignment, and have added in some new activities and assessments that are really different than what I would have come up with on my own.

Providing Resources and Training is one of the primary functions of the STEM Academy and almost all participants were able to cite it as one of the major benefits of participating in the academy.

Participants are able to engage in self-reflection of their teaching practices and goals for their courses

The next theme identified from the interviews and focus groups is Self-Reflection. The self-reflection described by participants revolved around their personal teaching philosophy and approach to teaching in their classroom. For many of the participants, their teaching philosophy was reinforced and supported by the activities and discussions in the STEM Academy. This theme was observed in the comments of 8 out of 19 participants in the interviews and focus groups. This was often noted when participants were asked if their participation in the STEM Academy changed their teaching philosophy, they said it did not change because their philosophy already aligned with the STEM Academy's emphasis on evidence-based teaching practices and improving student learning.

Mary discussed the use of self-reflection to figure out what content is most relevant to her course and students, and avoid wasting lecture time on subjects that do not align with her learning objectives. She described the process saying:

> I've been cutting material just because I find it interesting to talk about, because I've been balancing the needs of the student versus my need to share stuff that I considered to be fun or interesting. That was the biggest challenge, because I realized 'oh no, maybe I don't have a reason to talk about this because it doesn't contribute to that learning outcome.'

For some, the dedicated time set aside for the STEM Academy meetings is a benefit in itself because it pushes them to participate in the self-reflection process. As Janet, a Chemistry faculty member, described in a focus group:

> I think it's also nice to just have a dedicated time every few weeks to just sit and not think about like the little granular things that I have to do for class and it's a good time to just kind of like sit back and look at it bigger picture which I wouldn't do otherwise. I don't think I would carve out time in my schedule to really like look into new activities or new like new ways of approaching classes. So to me, it helps with my time, I think.

Promoting self-reflection helps participants improve their approach to teaching their courses, and gives them time to analyze how they have been using the new resources and training the STEM Academy has provided.

Participants observe increases to student engagement in their courses after implementing evidence-based teaching practices

The next theme identified from the interviews and focus groups was Student Engagement. Participants described increased student participation in classroom activities and discussion, as well as active use of the course concepts and materials. Student engagement can be seen when students actively participate with the lessons, content, and each other during a course. This theme was observed in the comments of 16 out of 19 participants in the interviews and focus groups. Part of the goals of the STEM Academy is to help its participants understand what evidence-based teaching looks like and how an active classroom functions. Many focus group attendees when asked, "If you were to walk into a classroom that was using evidence-based teaching practices, what kinds of things would you see and hear?" mentioned student engagement. For example, Doug, a Mathematics and Statistics faculty member, responded with, "I can see engaged students talking with themselves talking with the professor. Talking and trying things. Hopefully getting some stuff right and probably getting some stuff wrong, but not getting discouraged by it." While Felicia, a Biological Sciences faculty member, stated:

> Probably the students would be more. I guess interacting with each other, trying to figure out that evidence. Um and connecting it. That's at least the idea of connecting with the topics. Hopefully, there's a little more interaction between students, which sometimes is lacking. Um, there's interaction with the instructor and then there is no interaction.

And Peter, a Geography and Earth Science faculty member's answer was:

> Yeah, I think the word that comes to mind to me is "engagement", which is kind of both what you all have described is that whether it's the students engaged with material or an experiment, or in some of my cases, it's rock samples that I've passed out or with each other

> that they're essentially engaged in some sort of Process or activity, and not just sort of passive receptacles, so to speak for a lecture.

Student engagement was one of the primary signs of evidence-based teaching practices being used in a classroom according to the participants in the STEM Academy.

Increase student engagement was a goal for some participants, and Jane, a Mathematics and Statistics faculty member, described her success with the help of the STEM Academy:

> Because allowing this space for me to be able to explore all these different ideas, you can really start to see a change with the students as well. Most specifically in my head I'm thinking about the geometry course, because that's the one we started four years ago.

She went on to describe how changing her class translated to getting positive results in the higher level classes that followed. The other instructors reported that the students who took her class the previous semester were more engaged in the material and had a more positive attitude towards the related content in the upper level courses.

Participants appreciate the collaborative process of the STEM Academy and the community that is built

Another theme identified from the interviews and focus groups is Collaboration and Building Community. The STEM Academy is structured as a faculty learning community, and utilizes group discussion, collaborative projects, and sharing resources and feedback during and outside of its meetings. This theme was observed in the comments of 16 out of 19 participants in the interviews and focus groups. Many of the participants described building community with their colleagues inside and outside their departments as a major benefit of the STEM Academy experience. While the STEM Academy participants were tasked with working on a team from their discipline to create a project, when talking with participants, many highlighted how much they enjoyed working with faculty members from other STEM disciplines than their own. Jon, a Mathematics and Statistics faculty member, stated:

> It is multifaceted how great the STEM Academy was. Especially having the ability to work outside of our department of reach out to these other departments and seeing what they're doing firsthand. Usually what I get is for my students and they tell me what they're doing in their other classes, but first hand from the other instructors themselves. We hear from them on things that they tried to do and this thing worked and this thing did not work. So we looked at things that literally did not work and that's also learning about how to fix it. All in all the STEM Academy has been superb. I have thoroughly enjoyed it.

In a large university setting, opportunities to learn from other departments are not easy to schedule and execute. The STEM Academy allowed STEM faculty members who would not usually have opportunities to collaborate at a specific time and structure to do so.

As a faculty learning community, the STEM Academy participants described the benefits of building community with faculty members from across the campus that shared their teaching philosophy and goals of improving student instruction in their classes. In a focus group, Peter said:

> The best thing about STEM Academy for me, has been taking people who have the same sort of mentality about teaching as those involved in ALA [Active Learning Academy] but who are disciplinary adjacent and who I think Grace said you know, understand the problems that I'm dealing with that are very specific to how my classes work. And just tapping into that group of people who have great ideas and have the same interests as I do. And understand the problems in sort of the same way I do is very helpful.

And Doug, when asked "What aspect of the STEM Academy has been the most impactful for your professional development", he said:

> Honestly, just the personal relationships and seeing a room full of people that actually care about teaching… At least in our department, you're not generally, you're not going to walk into a room where that many people care that much about what's going on in the classroom. Sorry, it's kind of nice to see everybody pulling into the same direction.

The participants have stated that the STEM Academy was able to build a community of STEM faculty members that fostered collaboration and motivation with each other to incorporate evidence-based teaching practices in their classrooms.

Participants find the encouragement to choose small, achievable goals helpful when adopting new practices in their courses

Another theme observed in the interviews and focus groups is the STEM Academy's emphasis on encouraging participants to try to complete one small, achievable goal in their classroom as an introduction to evidence-based teaching practices. In the interviews and focus groups 7 out of the 19 participants mentioned this theme. For example, Jon described the approach encouraged by the STEM Academy in his interview:

> Well, number one we went from traditional lecture, lecture, lecture, to changing up our lecture. And we did it with what we called small changes, and it was brilliant. You just can't turn on a dime with this stuff. We got things in place, we still have to do lecture I mean that's just part of what we're covering material like that. But how we lecture, really the small changes, you know putting in a learning activity here, changing the way that I lecture such that it's more interactive with the students, and more of open-ended style

> questions while I'm trying to get across... And again it started with the ideas we got from the academy. We did it was small changes slowly over the semester. It was gradual and that was the best way to do it. You can't just go, 'we want you to redesign calculus how you teach it.' That's not going to work. No professor is ever going to join any stuff like that. The small change mindset was brilliant.

While many of the participants had stated that their teaching philosophy already mirrored that of the goals of the STEM Academy, many had not put these ideas into practice or had the resources to do so. The small change approach was less intimidating for those who were new to evidence-based teaching practices.

Peter described incorporating small changes as an experiment. The STEM Academy had shown him new practices and encouraged him to try our small changes to see what worked and what did not over time. And Jasmine described her process in bringing in a small change of a hands-on activity in her course. She tried the activity and then was able to receive feedback and encouragement through the STEM Academy leaders and the other participants to continue improving the new activity and its execution in her classroom.

Participants appreciate the focus on resources and training that is relevant to the STEM experience

Another theme from the interviews and focus groups is Relevance to the STEM Experience. Participants made note that, while there are other learning communities and professional development opportunities on campus, they are not often geared toward STEM courses. In the interviews and focus groups 8 out of the 19 participants mentioned this theme. For example, Grace, a Mathematics and Statistics faculty member, described her experience in STEM Academy compared to a broader program, the Active Learning Academy (ALA):

> So I had done, there was an adjunct cohort that went through for the Center for Teaching and Learning and I learned a whole bunch and I was starting to get into the active learning stuff. I went to the ALA, but they always recommended things that didn't feel like they applied in my discipline. So, when I heard about the STEM Academy, I was like, 'okay, this is Active Learning, but for me for my courses', like it's going to fit my courses better and, and really looking forward to the opportunity… to collaborate with people in disciplines that weren't mine, but were like mine kind of to see what they were doing.

Having resources, training, and collaborators that are specific to one's own discipline was important and beneficial to some of the participants in the STEM Academy. STEM disciplines have unique needs due to the nature of the content and what type of tasks and objectives students are being asked to complete. Not all training and resources for incorporating evidence-based teaching practices can be easily applied to all disciplines.

Participants found the focus on STEM disciplines made the STEM Academy a better use of their time and efforts than other learning communities or professional development programs. Elaine, a Geography and Earth Science faculty member, described how the STEM Academy felt different than other professional development:

> It's just really nice to work with people who are like-minded, but are in adjacent disciplines. And the things that I never thought that I might be able to learn from a chemist or a physicist for example, you know, is really not the case. There are some

> things that translate very well no matter what I'm teaching, so it's just nice to be with the community.

This theme shows some overlap between the themes of community building as well as the resources and training unique to the STEM Academy.

Participants struggled with implementation of new practices due to time constraints within and outside the classroom

While the previous themes identified from the interviews and focus groups describe the benefits the participants experienced in the STEM Academy, the following themes are indicative of some of the challenges experienced. One challenge that was frequently described is Time. In the interviews and focus groups 8 out of the 19 participants mentioned this theme as a barrier to implementation. Participants described challenges with the limited time they have to plan new lessons and design new activities, as well as the limited class time they have to cover all of the material while attempting to use these new evidence-based practices.

When asked in their interviews, "What challenges did you face in implementing this change", colleagues had responses that conveyed both ways time can be a challenge. For example, Jake, a Mechanical Engineering faculty member, stated, "The time commitment, not so much the time commitment of me creating it but the time at the end of class takes time away from content." And Makayla, a Chemistry faculty member, described her experience:

> It was time. I need the time to think about it, I need the time to introduce it in my course. How to integrate it seamlessly in my course in the middle of a semester. That was my challenge because it is always a constraint for time. I also had to think of 'what I am missing? What do I want to introduce without them having to miss it.'

Whether it is the limited planning time before class or the class time itself, evidence-based teaching practices demand more time than a traditional lecture lesson plan, especially when first incorporating them into a course.

Some participants struggled with incorporating the new practices, and this struggle can lead to feeling discouraged from continuing with the new activities and relying on more traditional methods. Janet described her experience:

> I think time management is a big problem for me in some of these activities also because I know how to get through material fast when lecturing, but that doesn't mean it's effective. … That's one of my biggest hindrances in some of these things is I don't know how to cover all the material and still effectively get through it all.

Steve, a Chemistry faculty member, explained that since his time at the STEM Academy, he has incorporated the evidence-based teaching practices less often in his larger classes due to time constraints:

> And so, I spend less than each year past. The time I was told to do these great things, I spend less and less time doing those activities in class. Because I still feel like what I deliver in the classroom is more valuable than them sitting there talking about a problem for five minutes.

Gaining the training and resources for evidence-based teaching practices is not always enough to get faculty members to make permanent and consistent changes to how they teach their courses, due especially to time constraints. This common problem is summed up well by the sarcastic quip from Jane, "I just need like an extra 12 hours a week and then we'll be golden."

Participants found student resistance a barrier to implementing new evidence-based teaching practices

The theme of Student Resistance was identified in the interviews and focus groups. Student resistance encompasses the negative attitudes and feedback to changes in classrooms such as alternative assessments and active learning activities, as well as non-participation by students in new activities. Getting buy-in from students is important to the efficacy of evidence-based teaching practices, and most instructors noted that the students who are resistant to these practices are in the minority of the student population. In the interviews and focus groups 10 out of the 19 participants mentioned student resistance as a barrier to implementing new practices. For example, Nancy, a Computing and Informatics faculty member, explained that it is a deterrent to trying these new practices in the classroom because students who are resistant will leave negative comments on course evaluations and may contact the Dean in order to lodge a complaint. So, even though these students are in a minority, the administration takes more notice of their resistance than the positive outcomes of using evidence-based practices in the classroom.

Netty, a Physics faculty member, explained how it is more difficult to reap all of the benefits of incorporating these practices if students do not take responsibility for their own learning and participate in the process. Students that are not completing readings or homework outside of class time will not be able to effectively participate and contribute to active learning lessons, leading to falling further behind in the course content. This creates frustration for both students and instructors and lessens the motivation to use evidence-based teaching practices in the future.

Despite student resistance, the participants in the STEM Academy believe the evidence-based practices are better for student learning overall, and choose to trust that they know better than their students about how to run their classes effectively. Jake described his experience with his engineering students:

> I like that it, breaks up the class, it allows the students to interact with one another. There's all these benefits but the downside is people who dislike to listen to the instructor. I have quite a few of them in engineering saying 'oh I just want a lecture'. Well that's not the best way but... That's kind of a challenge – changing the students mind.

And Georgia explained that she has seen students overcome their resistance once they give the new practices a chance:

> So, students can be somewhat resistant to change in class, and especially with active learning they tend to sometimes not think that they want to engage in it. But once they become engaged, I think that it is worth doing the change, and worth practicing something new.

Participants found the lack of particular resources and spaces on campus a barrier to implementing new evidence-based practices

Another theme identified from the interviews and focus groups is Lack of Resources. The resources needed by participants from the university are classroom facilities that are conducive to active learning, teaching assistant (TA) support to help with facilitating activities during class time and grading assignments, and other resources like new technology or subscriptions to services that help with student engagement. In the interviews and focus groups 8 out of the 19 participants mentioned this theme as a barrier to implementation.

Netty described her challenges with creating assignments with open-ended questions that encourage more critical thinking from students:

> Well I always made my own questions. That is not the problem; the problem is that I need more manpower, because somebody has to create them. So that kind of limits me in what type of question I can ask. I mean, I do ask some questions that are computer graded, but to really make sure it is not just a random guess, I do like to use questions where they have to write something. So, the problem is getting enough manpower to grade it.

TAs are not only needed for help with grading more frequent assignments, but also to help facilitate learning activities with large class sizes. Jon shared his experience with trying to manage classes of 120 or 150 students:

> …with these large classes to allow us to be able to when we do these learning activities at least having more boots on the ground being able to go from group to group to group as they're working on it. Making sure they're on task, if they have any questions they can answer them quickly, as we move through the classroom.

Jon also describes issues with classroom layouts for facilitating group work. If the desks are in fixed places it can be difficult to group students effectively for group discussion and active learning activities. There are only a few classrooms that are designed to promote active learning where students can easily work in small groups. As these evidence-based practices have become more popular, these few classrooms are being reserved more frequently by faculty members. Also, Jane described her efforts to try to use evidence-based teaching practices with virtual classes. While faculty members have access to Zoom and a few free online resources, other tools that can be especially useful in STEM courses require paid subscriptions that need to be approved by departments.

Participants found the resistance to change by their colleagues outside the STEM Academy a barrier to implementation of new practices

Another theme identified from the interviews and focus groups is Colleague Resistance. This was identified when colleagues outside of the STEM Academy show push-back or apathy towards making changes to how they teach in their classrooms. This type of resistance may be due to lack of buy-in that evidence-based teaching practices are worth the time and effort compared to lecture based lessons. In the interviews and focus groups 13 out of the 19 participants mentioned colleague resistance or apathy. Felicia described her experience with trying to share what she has learned in the STEM Academy:

> And the discussions with colleagues, I think varies if they are part of STEM Academy or are interested in active learning or in newer techniques that we're trying to learn or discuss. They like it, or they're all for it, but then I have also seen [sic] some faculty members that think this is a total waste of time. 'Why are you trying to reinvent stuff?' 'You go in the front of the classroom, speak, you're done. That's it.' I've seen that type of [sic] reaction as well, not necessarily administrators.

Just like students, faculty members can often be resistant to change from the familiar teaching methods that were used when they were students. Nancy observed that she hears more resistance from tenure-track faculty members that prioritize their research over experimenting with their instruction in classes. This reaction may seem reasonable due to the pressures of maintaining their funding and continuing to contribute to the literature. Nancy explained that she felt it neglected the needs of the students and keeping current with teaching practices.

Participants in the STEM Academy are encouraged to bring the resources and training they gained back to their departments. It can be challenging to make consistent changes to courses when they are often taught by part-time instructors or Ph.D. students. Kalvin, a Geography and Earth Science faculty member, described efforts to create universal modules that can be used by any instructor coming into the department so that students can receive consistent and quality instruction. This plan would sacrifice the autonomy in the classroom of these instructors, and is often met with resistance as a result.

Participants experienced a lack of appreciation of their effort to implement new practices from both students, colleagues, and administration

The last theme identified from the interviews and focus groups is Lack of Appreciation for Effort. Participants experienced under- or no appreciation of the amount of work and time it takes to teach using evidence-based teaching practices. This lack of appreciation was identified coming from their administrators, their colleagues, and their students. In the interviews and focus groups 8 out of the 19 participants mentioned this theme. When participants were asked "Were your efforts to transform your course(s) supported and recognized by your department, college, and university" some noted that they felt supported, but others said that there is a lack of awareness or apathy towards their efforts. Support can vary between departments, but several participants described that they are not celebrated for their efforts the way their colleagues are for publishing research. Peter describes feeling as though the only factor that would catch the administration's attention is lower drop fail withdraw (DFW) rates. He stated, "The only time most of us hear about teaching is if something goes wrong." This sentiment was reiterated by Doug when he said, "So the administrators I've been around are happy as long as they're not being bothered by your students." Grace described feeling like the participants from the STEM

Academy are viewed as "some kind of weird cult" due to their interest in evidence-based practices that lie outside the interests of other faculty members.

When describing issues with student resistance, participants often described feeling wrongfully accused of "not teaching" due to the nature of active learning facilitation. Participants would feel frustration that their efforts to design and execute engaging lessons were viewed as "lazy teaching" and a "waste of time" by students who did not understand the work that went into designing the activities and why these practices were being used in the classroom.

Discussion

The results from the interviews and focus groups with the participants from the STEM Academy have answered the research questions posed for this aim. The first research question asked "how did the STEM Academy influence teaching practices." From the results, there are examples showing participants created and revised their learning and course objectives, created alternative assessments based on student feedback, experimented with newly acquired resources and training with evidence-based teaching practices to make small changes to their teaching practices, and worked to increase student engagement in their courses.

The second research question wanted to identify the barriers participants experienced to implementing desired evidence-based teaching practices. There were five themes identified that pertain to barriers or challenges to implementing new evidence-based teaching practices. These themes were time, student resistance, lack of resources, colleague resistance, and lack of appreciation for effort. Time was a significant barrier to implementation because lessons that utilize evidence-based practices take time to create, and the planning time of faculty members is limited by their other duties and obligations for their jobs. Also, class time is limited with students, and often evidence-based practices take more class time than traditional lecture lessons. This creates an issue of covering all of the required material for the course within the semester schedule. Student resistance to change created a barrier to implementation because dealing with student complaints can be stressful during class time while instructors are attempting a new practice. Student complaints can also create stress for instructors if they feel they will lose the support of their department chair or dean for implementing evidence-based practices. Active learning requires student buy-in and participation to be effective, and student resistance is a barrier to successful implementation of active learning in the classroom.

The lack of resources theme identified the need for classrooms that are designed to help facilitate active learning. Active learning often requires students to work in small groups for problem solving and discussions. When most large classrooms on the campus are designed as lecture halls, it is a barrier to implementing active learning lessons. Evidence-based teaching practices can also require more open-ended assignments that take longer to grade and given important feedback to students. While these assignments are good for critical thinking, their implementation is challenging due to lack of TA availability for executing grading. TAs are also very useful when facilitating active learning activities in large classes. An instructor can only answer one question at a time, so having help from TAs with facilitation and answering questions during an active learning lesson would help with implementation of evidence-based teaching practice. The theme of colleague resistance was the most frequently cited barrier to the goal of bringing the resources and skills acquired by participants in the STEM Academy back to their departments to implement evidence-based practices in more classes. Similar to student resistance, colleagues that have not participated in the STEM Academy can be resistant to being asked to try new ways of teaching and it can be challenging to convince them that these practices are worth the effort for implementation. Instructors value their autonomy in the classroom and often believe that the traditional lecture methods are sufficient to effectively teach their students. This colleague resistance is linked to the final theme related to barriers to implementation. Lack of appreciation for effort can come from colleagues, administrators, and students. Implementing evidence-based teaching practices is a laborious task that requires time and courage from the instructor to create and try something new. When those efforts are under or not appreciated by the rest of the academic community, it can be discouraging to progress and instructors may lose motivation or interest in continuing to implement new practices in their classroom.

The third research question focused on identifying the benefits of participating in the STEM Academy. There were six themes that identified benefits; resources and training, self-reflection, student engagement, collaboration and building community, small achievable goals, and relevance to STEM experience. The STEM Academy utilized the meetings to share resources and provide training for evidence-based teaching practices. Participants identified new resources and skills they acquired while participating in the STEM Academy that they then used in their teaching practices. Participants were prompted during meetings to reflect on their teaching practices and goals. This dedicated time to self-reflection was identified as a benefit by participants. The self-reflection helped with identifying issues participants could bring up for discussion and feedback from their peers and created a space that encouraged being intentional with their teaching and goals as an instructor. Participants also observed increased student engagement in their classrooms from the implementation of the evidence-based teaching practices taught at the STEM Academy. Increased student engagement can create a better learning environment and better student outcomes.

The STEM Academy is designed as a faculty learning community, and many participants said they benefited from the collaboration and community that was built within it. Collaboration could occur between faculty members of the same discipline, and across disciplines within STEM. The community building allowed for participants to share resources, give each other feedback, and share their stories of successes and failures with the new evidence-based teaching practices. Many participants said they benefited from the STEM Academy's encouragement to set small, achievable goals for trying new practices in their classrooms. This helped ease participants' anxiety about changing their teaching practices and helped to not overwhelm instructors with trying to completely redesign a course all at once. Having small, achievable goals allowed for more success with initial changes to instruction which built up the confidence of the participants. The final theme identified as a benefit to participants in the STEM Academy was the relevance to the STEM experience compared to other faculty learning communities and professional development programs. STEM courses have unique needs due to the nature of the content and what type of tasks and objectives students are being asked to complete. Participants said they found other programs that promoted active learning were not as beneficial to them because the examples and resources provided did not translate well to their discipline's curriculum. The STEM Academy focuses exclusively on how to implement evidence-based teaching practices in STEM courses, and this was seen as a better use of time and more effective than other programs by participants.

SUMMER VENTURES – AIMS 2 and 3

Background

"Summer Ventures in Science and Mathematics is a no-cost, state-funded program for academically talented North Carolina students who aspire to careers in science, technology, engineering, and mathematics" (North Carolina School and Science and Mathematics, 2023). Summer Ventures (SVSM) is a four-week summer program that teaches exceptional high school students about a particular topic in science or math, and coaches them to design and conduct their own STEM research projects. SVSM is hosted by four universities in North Carolina, one being UNC Charlotte. Students in SVSM spend four weeks (one virtually and three in person on campus) learning about a particular topic in science or math and designing, conducting, and presenting their own original research project. Other courses in SVSM cover such topics as biology, physical science, data science, and mathematical modeling. SVSM is a student-centered learning experience that focuses on nurturing STEM exploration and research.

A Nanoscale Science course was developed for SVSM on the UNC Charlotte campus by myself along with Alex Rolband and Yizhou Wang. The course curriculum is based on the NSTA publication "The Big Ideas of Nanoscale Science and Engineering: A Guidebook for Secondary Teachers", the coursework associated with the Nanoscale Science Ph.D. program at UNC Charlotte, and based on example curriculum guides used for other STEM courses (Stevens et. al., 2009; Grant, 2018; Boyle & Charles, 2016). This course was first conducted with 15 participants in the summer of 2022. I was the lead instructor with Alex Rolband and Yizhou Wang acting as co-instructors. The participants completed research projects and submitted final papers at the end of the course. The students also completed the Student Attitudes in STEM Survey (S-STEM) at the beginning and end of the course.

The course curriculum and instructional design was revised and the course was conducted again in the summer of 2023. This second iteration was conducted with 12 participants with me as the lead instructor and Kanika Dhiman as the co-instructor.

AIM 2 – SVSM FINAL PAPER ANALYSIS

To assess the impact of the revisions made to the SVSM Nanoscale Science course between iteration 1 and iteration 2, I reviewed student outcomes via the student final papers. The papers were scored using a specifically designed rubric and the two cohorts were compared to identity changes. The following research questions were addressed:

RQ 1: How did changes to the SVSM Nanoscale Science course impact students' final papers?

RQ 2: How did changes to the SVSM Nanoscale Science Course impact student understanding of Big Ideas in Nanoscale Science (BINS) and research design techniques?

Methodology

Revisions were made to the SVSM Nanoscale Science course between the 2022 and 2023 iterations of the course. These revisions fell under two main categories of curriculum development and instructional design. The initial curriculum approach for the summer of 2022 focused on mostly Chemistry and Physics concepts based on the prerequisite knowledge requirements for the objectives based on the BINS. For the second iteration, more Biology concepts were added based on student interest during the first iteration. This interest was most likely due to the students' more recent experiences with Biology classes in their highs school course of study as well as its potential for research projects that are more accessible to students at the high school level.

The major concepts, referred to as "Big Ideas" in the text, for Nanoscale Science outlined in the (Stevens et. al., 2009) publication are:

1. Size and Scale – “Factors relating to size and geometry (e.g., size, scale, shape, proportionality, dimensionality) help describe matter and predict its behavior.” p. 5
2. Structure of Matter – “Materials consist of building blocks that often form a hierarchy of structures. Atoms interact with each other to form molecules. The next higher level of organization involves atoms, molecules, and nanoscale structures interacting with each other to form nanoscale assemblies and structures.” p. 10
3. Forces and Interactions – “All interactions can be described by multiple types of forces, but the relative impact of each type of force changes with scale. On the nanoscale, a range of electrical forces with varying strengths tends to dominate the interactions between objects.” p. 18
4. Quantum Effects – “Different models explain and predict the behavior of matter better, depending on the scale and conditions of the system. In particular, as the size or mass of an object becomes smaller and transitions through the nanoscale, quantum effects become more important.” p. 24
5. Size-Dependent Properties – “The properties of matter can change with scale. In particular, during the transition between the bulk material and individual atoms or molecules – generally at the nanoscale – a material often exhibits unexpected properties that lead to a new functionality.” p. 37
6. Self-Assembly – “Under specific conditions, some materials can spontaneously assemble into organized structures. This process provides a useful means for manipulating matter at the nanoscale.” p. 43
7. Tools and Instrumentation – “The development of new tools and instruments helps drive scientific progress. Recent development of specialized tools has led to new levels of

understanding of matter by helping scientists detect, manipulate, isolate, measure, fabricate, and investigate nanoscale matter with unprecedented precision and accuracy." p. 54

8. Models and Simulations – "Scientists use models and simulations to help them visualize, explain, predict, and hypothesize about the structures, properties, and behaviors of phenomena (e.g., objects, materials, processes, systems). The extremely small size and complexity of nanoscale targets make models and simulations useful for the study and design of nanoscale phenomena." p. 58
9. Science, Technology, and Society – "The advancement of science involves developing explanations for how and why things work and using technology to apply that knowledge to meet objectives, solve problems, and answer questions of societal interest. Because nanotechnology is an emergent science, it provides an opportunity to witness and actively participate in scientific progress and in decision making about how to use new technologies." p. 65

When comparing the BINS to the Essential Standards set by the NCDPI for the subjects of Chemistry and Biology, these high school courses lay the foundation for student's understanding of Nanoscale Science. Below is a table in which BINS is supported by particular standards from both the Chemistry and Biology NCDPI standards. The NCDPI standard and the corresponding BINS are organized in Table 1.

The initial approach with the instructional design of the course was focused on incorporating active learning, student-centered learning, scientific literacy, laboratory exploration, and experimental design. The four-week course begins as with the first week being structured lecture-based learning along with exploration activities and cognitive processing exercises at the beginning when reviewing Chemistry and Biology concepts and learning new BINS. The group laboratory exercises are facilitated by the instructors beginning in the second week of the course along with guest lectures from UNC Charlotte faculty and laboratory tours.

Table 1

NCDPI Standards and Related Big Ideas in Nanoscale Science

NCDPI Standard	Related BINS(s)
Chm1.1 – Analyze the structure of atoms and ions	1, 2, 4, 7, and 8
Chm1.1.3 – Explain the emission of electromagnetic radiation in spectral form in terms of the Bohr model	8
Chm1.2.3 – Compare inter- and intra-particle forces	3 and 6
Chm1.3 – Understand the physical and chemical properties of atoms based on their position on the periodic table	5
Bio1.1 – Understand the relationship between the structures and functions of cells and their organelles	1, 2, and 8
Bio4.1 – Understand how biological molecules are essential to the survival of living organisms	1, 2, and 3
Statement for both Chemistry and Biology Standards – Teachers, when teaching science, should provide opportunities for students to engage in "hands-on/minds-on" activities that are exemplars of scientific inquiry, experimentation and technological design.	9

Note. List of NCDPI standards from high school Chemistry (NSDPI, 2016b) and high school Biology (NCDPI, 2016a) and their correlating BINSs (Stevens et. al., 2009)

The individual research projects are student-led and instructors act as mentors for students as they design and execute their own experiments. For their individual research projects, students begin brainstorming in the first week, researching and designing the procedure in the second week as they become familiarized with laboratory techniques, and execute the experiment in the second and third weeks of the course. The fourth week of the course is dedicated to finishing data analysis and completing their final papers and presentations. In Table 2, the revisions made to the course after the first iteration are explained along with the rationale behind the revisions.

Table 2

Revisions Made to SVSM Nanoscale Science Course

Instructional Revision Made	Rationale
Increased interaction with journal articles – Students were given more journal articles to read, and the practice sessions were scaffolded to include more guidance on how to approach reading a journal article, and were done in pairs.	Reading journal articles is a skill set that most students at the high school level have not experienced. The final project requires students to research and write a literature review. We added more guidance and had them work in pairs to improve comprehension
Ordering supplies for anticipated individual projects and increasing guidance for students with their project design – Potential student projects were researched and the supplies for particular projects were purchased in anticipation of students being advised on these projects.	G1 students struggled with choosing projects that were feasible and closely related to the content. We decided to choose a few broad projects that could be chosen and personalized by students in G2 to alleviate some of those challenges and give them a better foundation to their projects.
Implementing more draft review and peer review of final projects – Students received feedback at two stages of the draft process, one by the instructor and a formalized peer review	Giving students more feedback throughout the process aims to improve the overall results of the projects and give students experience with evaluating their own and others' work.
Implementing a mini-research presentation – Students worked in small groups to present on a chosen characterization instrument	Having a mini-research presentation gives students an opportunity to practice and prepare for their final project presentation at the symposium
Revising data collection and reporting for group lab experiments – The group lab experiments were given more formal write-ups for students to report their data and draw conclusions.	Adding more lab reports to the course gave students more experience with analyzing their data and drawing conclusions from the results. These reports were given feedback to help students improve their skills.

Note. Chart describing the revisions made to the SVSM course between the first iteration in 2022 and the second iteration in 2023 and the rationale for these revisions.

The revisions made to the second iteration focused on reading more journal articles, having students do more practice presentations before the symposium at the end of the program, offering more opportunities to synthesize material in chunks during the beginning of the course, and giving more opportunities to share how they synthesize material with their peers. Students were also given a list of available materials and possible ideas for projects early on in the program so they could start their research earlier to prevent delays resulting from troubleshooting and getting materials ordered. Table 2 contains a summary of the revisions and rationale behind changes that were made to the course for the second iteration.

The Nanoscale Science course was designed from a top down approach. Summer Ventures Science and Math (SVSM) is a program with its own goals and basic structure within which the Nanoscale Science course needs to work. The parameters of SVSM is a four week program, with the first week done virtually, in which students learn content on a particular subject and conduct an original research project on that subject that is presented at the end of the program (North Carolina School of Science and Mathematics, 2023). The goals of SVSM are to build new knowledge in the course topic and to develop critical thinking and research skills. With these goals in mind, the learning objectives for the course were designed to meet these goals. Objectives should describe the terminal behavior (what the student will be doing once they have achieved the objective), state the criteria for an acceptable performance, and include any qualifying conditions (Boyle & Charles, 2016, p. 115). Having learning objectives that are measurable makes it possible to assess student learning and assess the effectiveness of the course based on student achievements of the objectives.

The syllabus and schedule for the SVSM Nanoscale Science course is based on the advice and experiences of past instructors for other SVSM courses during an informational planning meeting held on February 3rd, 2023. During this meeting it was established that content should be covered mostly during the first and second week of the program. During the second and third week of the program, blocks of time should be set aside for students to work individually on their research projects. The fourth week of the course is devoted to completing the research projects with peer and instructor feedback sessions and practice presentations.

Learning objectives for the content knowledge of the course were designed based on the BINS while taking into account the North Carolina Department of Public Instruction Essential Standards for Chemistry and Biology (NCDPI, 2016a, NCDPI, 2016b, Stevens et. al., 2009). The first week of the course is dedicated to covering course content on Nanoscale Science as well as some brainstorming time for developing their research project ideas. As this week is conducted virtually, the lessons were planned to optimize the experience through the use of online tools and technology. Once students are on campus, the course is designed to build student laboratory and research skills through group lab experiments that tie to the major concepts covered in the first week of the course.

The pedagogical practices utilized when designing the individual lessons and activities for the course should be based on evidence-based teaching practices, the objectives of the course, and evidence-based learning theories (Plomp & Nieveen, 2007). Cognitive learning processes have been studied to gain understanding about how the brain learns new information and solves problems (Schunk, 2012). Understanding cognitive learning processes as well as metacognition when designing lessons and activities will improve the efficacy of the course (McGuire, 2015). The Nanoscale Science course is based around student-centered learning principles that help increase learner motivation and promote higher order thinking on the content (Collins & O’Brien, 2003). At the beginning of the course, when most of the new content is being taught, students were tasked with processing the information in multiple ways to improve cognition and address different learning styles. Students used online interactive tools, games, videos, discussions, debates, and creative expression through drawings and storytelling to understand and apply the new content in different ways. These active learning strategies along with some traditional lecture were used to give students more opportunities for higher order thinking. The structure of the course and the small class size (15 students in cohort 1 and 12 students in cohort 2), allowed for the student-centered learning approach. Students had choices with which journal articles they read based on their individual interests, the topic of their mini-presentations, as well as the topic and design of their individual research project. The artifacts collected (student final papers on their individual research projects) and their assessment is based around the larger course goals and the results are used to make improvements to the course.

A rubric was developed based on the Junior Science and Humanities Symposium Judging Score Sheet and the BINS (Stevens et. al., 2009; Junior Science and Humanities Symposium, 2018). The rubric was evaluated by doing a sample assessment and scoring six student final papers by two reviewers and assessing how closely the scores aligned. It was found during the discussion meeting following this trial evaluation of the rubric that although the scores were similar between both reviewers, there was not enough distinction between the levels within the rubric categories to distinguish between the levels of the student final papers. Many of the scores were in the highest category established by the initial rubric. The rubric was revised from four levels to five to allow for more nuance and distinction in the scoring of the student final papers. This rubric can be found in its entirety in Appendix B.

The rubric consisted of four categories for evaluation with a scoring range from 1 – 5 for each category. Table 3 shows the description of the top score (5) for each category. These categories were chosen based on the section requirements of the paper.

Table 3

Superior Score Descriptions for Final Paper Rubric

Rubric Category	Superior (5)
Literature Review	Literature Review shows the author's deep knowledge on at least three BINS. The explanation is exceptionally thorough, accurate, and uses many reputable citations.
Research Questions	Research question is based on at least two BINS. The research question is very clearly stated. The research question is very innovative and based on exceptional understanding of existing knowledge in the literature.
Procedure and Data Collection	Experimental design addresses the research question very well. Experimental design identifies variables and controls. Experiment is run with an exceptional number of trials and is reproducible.
Discussion and Conclusion	Logical conclusion that is very relevant to the research question and the results of the experiment. Exceptional explanation of limitations and significance of results. Shows exceptional understanding of at least two BINS.

All student final papers were evaluated and scored using the rubric by three reviewers, each of whom acted as instructors for the course. These scores were recorded separately and independently. The scores were then collected and compared to find any discrepancies larger than one (1) level for each individual category on the rubric. Seven paper category scores (out of 108 total) were notated for evaluation due to a difference in score level being larger than one (1) between at least two reviewers. This small number of discrepancies shows the rubric is a reliable tool for evaluation of the student final papers. The scores that had discrepancies were discussed by all three reviewers and a consensus was reached by all parties to finalize scores within one level of each other. The finalized rubric data was analyzed by calculating mean values for individual categories for all papers, calculating means for each category for all papers within a cohort, and conducting Mann-Whitney U tests on the data to compare the student final papers from the two cohorts to each other using IBM SPSS software.

Results

Once all scores had been finalized by the reviewers, the scores for each category for each paper were averaged. The full data tables for the category scores and averages can be found in Appendix C. The mean for each category was found for the two cohorts overall. The first cohort from the summer of 2022 is represented as C1 and had a total of 15 students with 13 papers. Two of the projects from C1 were completed by a pair of students, rather than an individual. The second cohort from the summer of 2023 is represented as C2 and had a total of 12 students and 12 papers. All C2 papers were completed by individual students.

Table 4 shows the mean scores for each category for all C1 papers (C1 Mean) n = 13, for just the individually completed papers from C1 (C1 Adjusted Mean) n = 11, and for all C2 papers (C1 Mean) n = 12. These results show that there was improvement in all categories for the papers in C2 compared to C1. The significance of these improvements is explored through statistical analysis.

Table 4

Mean Rubric Scores for Rubric Categories of Final Papers

Rubric Category	C1 Mean	C1 Adjusted Mean	C2 Mean
Literature Review	2.87	2.70	3.17
Research Questions	2.56	2.39	3.28
Procedure and Data Collection	2.97	2.70	3.67
Conclusion and Discussion	2.67	2.52	3.33
Total Score	11.08	10.30	13.44

Note. Mean rubric scores by category for C1 (all papers), C1 Adjusted (only individual papers), and C2 papers.

The mean scores for C1 and C2 were compared using a Mann-Whitney U test. The Mann-Whitney U test was used due to the small sample size of the data (n = 27 for all papers, n = 25 for individually completed papers) and the lack of a normal distribution of the data. Table 5 shows the results comparing all of the C1 papers to all of the C2 papers. The results show significant improvement in the categories of Research Question ($U = 42.0$, $p = 0.05$), and Conclusion and Discussion ($U = 39.5$, $p = 0.03$). These results indicate that the revisions made to the course had a significant impact on student outcome. Students were able to write better research questions that integrated the BINS concepts for their projects. Students also wrote better conclusions to their projects, which could indicate deeper understanding of their work and better science communication skills.

Table 5

Mann-Whitney Test Results for All Final Papers

Mann-Whitney Tests on All Papers					
Rubric Category	**C1- n**	**C2 – n**	**C1 – Mean Rank**	**C2 – Mean Rank**	**Exact Significance (2-tailed)**
Literature Review	13	12	11.58	14.54	0.32
Research Questions	13	12	10.23	16.00	0.05
Procedure and Data Collection	13	12	10.92	15.25	0.15
Conclusion and Discussion	13	12	10.04	16.21	0.03
Total Score	13	12	10.42	15.79	0.07

Note. Mann-Whitney Test results, all papers. Significant p-values are highlighted in green.

The Mann-Whitney U tests were also run comparing the C1 adjusted means to the C2 means. The results of these tests are shown in Table 6. These results show that when comparing only the papers that were completed by individual students, there are significant improvements in all categories except the Literature Review. The categories of Research Question ($U = 27.5$, $p =$ 0.02, and Conclusion and Discussion ($U = 25.0$, $p = 0.01$) show even stronger significance than what was seen when analyzing all of the papers. There was significant improvement to the Procedure and Data Collection portion of the final papers (U = 31.0, p = 0.03). This could indicate that students gained a better understanding of experimental design. The significant improvement to the total score (U = 26.5, p = 0.01) comes from the gain across all categories of the papers. The student outcomes for the SVSM Nanoscale Science course have been significantly improved by the revisions to the course curriculum and instructional design. The overall improvement is further visualized in Figure 1.

When comparing the distribution of total scores on the papers, C1 students scored 2.4 points lower on average than C2 students. Figure 1 shows the distributions of the total scores for all papers from C1 and C2 students where the x-axis shows the full range of scores earned for all papers (between 6 and 18 total points out of a possible 20 total points) and the y-axis shows the number of papers which earned a particular total score. The trend lines in Figure 1 show the shift in the distribution of the scores on the papers from C1 to C2. When comparing the C1 adjusted mean (individual papers only) the difference increases to 3.1 points higher for C2 papers.

Table 6

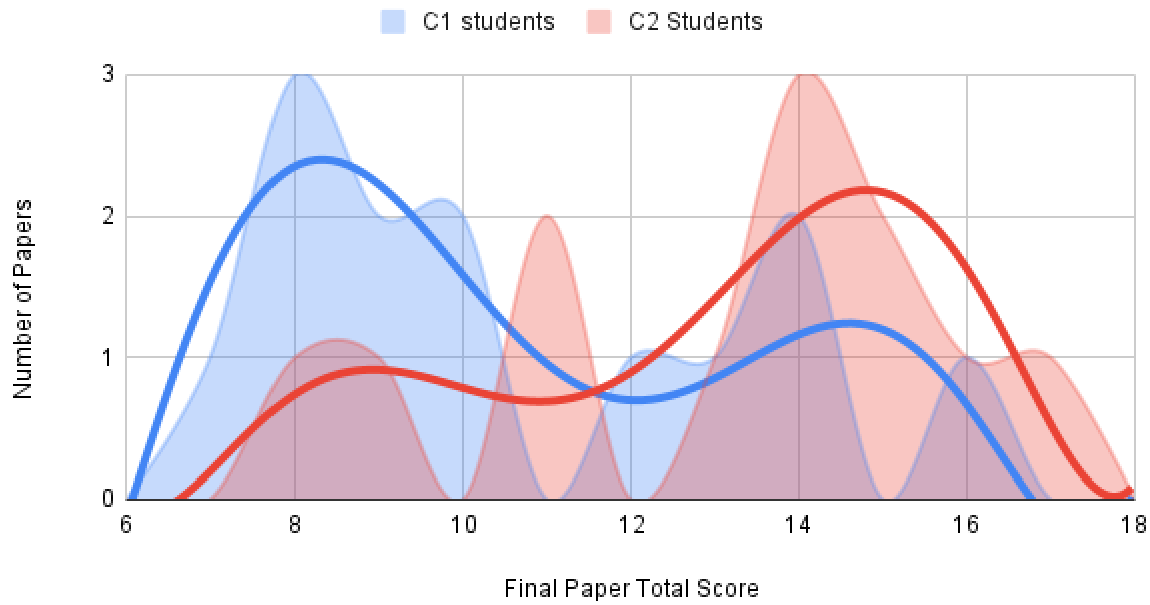
Mann-Whitney Test Results for All Individual Final Papers

Mann-Whitney Tests on All Individual Papers					
Rubric Category	**C1- n**	**C2 – n**	**C1 – Mean Rank**	**C2 – Mean Rank**	**Exact Significance (2-tailed)**
Literature Review	11	12	9.95	13.88	0.17
Research Questions	11	12	8.50	15.21	0.02
Procedure and Data Collection	11	12	8.82	14.92	0.03
Conclusion and Discussion	11	12	8.27	15.42	0.01
Total Score	11	12	8.41	15.29	0.01

Note. Mann-Whitney Test results, individual papers only. Significant p-values are highlighted in green.

Figure 1

Total Scores for C1 and C2 Students



Note. Area graph depicting the frequency of final paper total scores for C1 and C2 students. A polynomial trend line is shown for each cohorts' score data.

Discussion

The significant improvement across three out of four rubric categories as well as the overall scores shows that the revisions made to the course curriculum and instruction have positively impacted student learning outcomes. Due to making several changes to the course at once, it is not possible to pinpoint which revisions made the greatest impact from this data alone. This data can also show where further improvements can be made.

The Literature Review is the lowest scoring category for the C2 student papers. Increasing the number of journal articles students read and using guided reading procedures has increased the score in the Literature Review category between C1 and C2 students, but not significantly. The most common reason that students were not scored higher for this category is that their literature reviews were not thorough enough in explaining the background knowledge necessary for their research. Adding in activities where students explore the purpose of a literature review and what questions it should answer about their subject matter could help improve the scores in this category for future cohorts. Other categories could be improved through giving more feedback during the writing process by assigning a first draft earlier in the course timeline that will be reviewed by the instructors. This will allow for time for a second draft cycle before the final papers are due. To make these changes possible students will need to be further along in their planning and research. This will require earlier commitment to a project, which can be achieved by continuing with the revision of ordering supplies for anticipated individual projects and increasing guidance for students with their project design.

AIM 3 – SVSM STUDENT ATTITUDES TOWARDS STEM

I used a quasi-experimental design to explore the effects of participating in the SVSM Nanoscale Science course on student attitudes towards STEM (Mertens, 2015). Students who participated in the SVSM program completed The Student Attitudes towards STEM (S-STEM) survey on the first day of the course and during the last week of the course to understand if their attitudes towards STEM have changed as a result of taking the course. This instrument was used to evaluate and understand the impact of the Nanoscale Science course on students. The S-STEM survey was developed by The Friday Institute for Educational Innovation at North Carolina State University in 2013 (Faber et al., 2013). The S-STEM Survey is used "to measure changes in students' confidence and efficacy in STEM subjects, 21st century learning skills, and interest in STEM careers" (Gormally, Brickman, & Lutz, 2012, p.1). The survey has questions that fall under six categories: Math, Science, Engineering and Technology, 21st Century Learning, Your Future, and About Yourself. Each category uses a Likert scale for data collection. The research questions for this aim are:

RQ 1 – What is the main effect of intervention for all participants in the SVSM Nanoscale Science course?

RQ 2 – What is the main effect of group regardless of the intervention for the participants in the SVSM Nanoscale Science course?

RQ 3 – What is the interaction between group and intervention (Intervention X Group) for the SVSM Nanoscale Science course?

Methodology

The S-STEM survey uses a Likert scale to have participants rate their level of agreement or interest in particular statements. The answer choices for the Math, Science, Engineering and Technology, and 21st Century Learning items are: Strongly Disagree (1), Disagree (2), Neither Agree nor Disagree (3), Agree (4), and Strongly Agree (5). For the Your Future category, participants are given different fields of study or careers and a description of the field. The answer choices for the Your Future items are: Not at all interested (1), not so interested (2), interested (3), and very interested (4). The last category of items is About You. The first three items use the answer choices: Not Very Well (1), Ok/Pretty Well (2), and Very Well (3) for participants to evaluate how well they did in certain subjects in school. The other six items in the About You category use answer choices: Yes (3), No (1), and Not Sure (2). The complete list of S-STEM survey questions used for this study can be found in Appendix D.

The survey was taken by students through Qualtrics for both the pre- and post-intervention data. There were 15 students enrolled in cohort 1, and 11 students completed both the pre and post surveys for C1 ($n = 11$). There were 12 students enrolled in cohort 2, and seven students completed both the pre and post surveys for C2 ($n = 7$). Participant birthdate as well as gender data was collected and was used to determine which data sets belong to each SVSM course. The data for the Nanoscale Science course was transcribed into numerical scores for analysis. The data was analyzed using a two-way ANOVA test. A two-way ANOVA test is used when one wants to understand the interaction between two independent variables on a dependent variable (Laerd Statistics, 2024b). In this study, the two independent variables are the group which are the two cohorts (C1 and C2) and the intervention (participating in the SVSM Nanoscale Science course) while the dependent variable is the S-STEM survey ratings. I want to know if there is an interaction between the cohorts and the intervention on their attitudes towards STEM. A two-way ANOVA test analyzes the relationship between the main effect of intervention (comparing the mean results of pre and post surveys of all participants), the main effect of group (comparing the mean results of C1 and C2 for all surveys), and the interaction between intervention and group (intervention X cohort).

The two-way ANOVA test was run using IBM SPSS. All survey items were run individually and the data was collected into a table for each of the six categories. Effects that showed a $p \leq 0.08$ were highlighted for specific interpretation for trends or significance in the results. Mean scores were calculated for each item on the survey according to several groupings: C1, C2, pre survey, post survey, C1 pre survey, C1 post survey, C2 pre survey, and C2 post survey. The standard error was calculated for each mean value. The significance and f-value was calculated for the main effect of intervention, main effect of cohort, and the interaction between intervention and cohort. Complete data tables for each category from the S-STEM can be found in Appendix E. The items for each section were coded for ease of organization into tables. The math category items are indicated by "Math" followed by their number. For example, the second item of the math category is labeled: Math2. The other categories are coded as follows: Science – Sci#, Engineering and Technology – ET#, 21st Century Learning – Cent#, Your Future – YF#, and About You – AY#. These codes are used throughout the results tables.

Results

The results of the S-STEM survey for each of the six categories are reported and interpreted below.

Math

There are a total of eight items on student attitudes towards mathematics on the S-STEM survey. For the majority of the items on the survey, a higher score indicates a positive attitude towards the subject, however items Math1, Math3, and Math5 are opposite statements such as, "Math has been my worst subject." Therefore a lower score on these items reflects a more positive attitude towards the subject of mathematics by the participant disagreeing with the statement.

Table 7

S-STEM Survey Results for All "Math" Items

	Main Effect of Intervention			Main Effect of Group			Intervention X Group				
Item	Pre Survey Mean	Post Survey Mean	Pre vs. Post Sig.	C1 Mean	C2 Mean	C1 vs. C2 Sig.	C1 Pre Survey Mean	C1 Post Survey Mean	C2 Pre Survey Mean	C2 Post Survey Mean	Intervention X Cohort Sig.
Math1	1.38	1.54	0.11	1.27	1.64	0.23	1.18	1.36	1.57	1.71	0.84
Math2	3.83	3.82	0.96	3.86	3.79	0.86	4.09	3.64	3.57	4.00	0.13
Math3	1.82	1.82	1.00	1.64	2.00	0.32	1.64	1.64	2.00	2.00	1.00
Math4	4.51	4.40	0.60	4.55	4.36	0.59	4.73	4.36	4.29	4.43	0.23
Math5	1.70	1.49	0.14	1.41	1.79	0.27	1.55	1.27	1.86	1.71	0.64
Math6	3.97	4.21	0.20	4.32	3.86	0.26	4.36	4.27	3.57	4.14	0.08
Math7	4.36	4.79	0.08	4.73	4.43	0.28	4.73	4.73	4.00	4.86	0.08
Math8	4.51	4.49	0.91	4.64	4.36	0.36	4.73	4.55	4.29	4.43	0.37

Note. S-STEM survey results for all Math items. Significant or trending p-values highlighted in green.

There was a trend on Math6: "I am sure I could do advanced work in math", for the interaction between intervention and cohort, $F(1,16) = 1.39$, $p = 0.08$. While C1 rated themselves slightly lower post intervention, C2 rated themselves higher for post intervention compared to pre intervention (C1 pre survey item mean (std. error) = 4.36 (0.29), C1 post survey item mean (std. error) = 4.27 (0.25), C2 pre survey item mean (std. error) = 3.57 (0.36), C2 post survey item mean (std. error) = 4.14 (0.31)). These results could indicate that the first iteration of the course caused some of the students to feel less confident in their abilities in advanced math. However the second iteration of the course had the opposite effect, and students felt more confident about their potential in advanced math after the intervention.

The item Math7: "I can get good grades in math", showed a trend for both the main effect of intervention, $F(1,16) = 3.39$, $p = 0.08$, and the interaction of intervention and group, $F(1,16) = 1.25$, $p = 0.08$. When looking at the interaction between intervention and group, the C1 pre intervention mean and C1 post intervention mean are exactly the same (C1 pre survey item mean (std. error) = 4.73 (.11), C1 post survey item mean (std. error) = 4.73 (.28)). The trend comes entirely from the changes in C2, which shows an increase in mean rating between the pre intervention and the post intervention survey (C2 pre survey item mean (std. error) = 4.00 (0.36), C2 post survey item mean (std. error) = 4.86 (0.17)). This can indicate that the second iteration of the course gave students more confidence in their math skills, causing the increase to the rating mean post intervention.

In general, on positively worded items (Math2, Math4, and Math6 – 8), C1 averaged a rating of at least 3.86, and C2 averaged a rating of at least 3.79 for all items. Any rating of 4.00 and above indicates agreement with the statement, while a rating greater than or equal to 3.00 but less than 4.00 indicates neither agreeing nor disagreeing with the statement. On oppositely worded items (Math1, Math3, and Math5), C1 averaged a rating of at most 1.64, and C2 averaged a rating of at most 2.00. Any rating equal to or less than 2.00 indicates disagreeing with the statement. There was not a consistent trend of improvements of students' attitudes towards math across the eight items, which can be seen in Table 7.

Science

There were a total of nine science items on the S-STEM survey. Sci6: "I know I can do well in science", showed a difference between the two cohorts, *F*(1,16) = 0.95, *p* = 0.08. C1 rated themselves higher for this item than C2 (C1 item mean (std. error) = 4.77 (0.16), C2 mean item (std. error) = 4.29 (.20)). However, when looking at the comparisons between cohorts for their post intervention change, there is a greater rise in the mean for C2 than for C1 (C1 pre survey item mean (std. error) = 4.73 (0.28), C1 post survey item mean (std. error) = 4.82 (0.14), C2 pre survey item mean (std. error) = 4.00 (0.36), C2 post survey item mean (std. error) = 4.57 (.17)). This can indicate that C1 had more confidence in their science skills before the intervention, while C2 showed more growth from the intervention.

Table 8

S-STEM Survey Results for All "Science" Items

	Main Effect of Intervention			Main Effect of Group			Intervention X Group				
Item	Pre Survey Mean	Post Survey Mean	Pre vs. Post Sig.	C1 Mean	C2 Mean	C1 vs. C2 Sig.	C1 Pre Survey Mean	C1 Post Survey Mean	C2 Pre Survey Mean	C2 Post Survey Mean	Intervention X Cohort Sig.
Sci1	4.44	4.37	0.49	4.46	4.36	0.77	4.46	4.46	4.43	4.29	0.49
Sci2	4.84	4.81	0.75	4.86	4.79	0.65	4.82	4.91	4.86	4.71	0.17
Sci3	4.44	4.62	0.23	4.77	4.29	0.21	4.73	4.82	4.14	4.43	0.53
Sci4	4.53	4.62	0.53	4.86	4.29	0.11	4.91	4.82	4.14	4.43	0.23
Sci5	4.55	4.62	0.60	4.82	4.36	0.27	4.82	4.82	4.29	4.43	0.60
Sci6	4.36	4.70	0.20	4.77	4.29	0.08	4.73	4.82	4.00	4.57	0.34
Sci7	4.53	4.79	0.27	4.82	4.50	0.28	4.91	4.73	4.14	4.86	0.07
Sci8	1.49	1.42	0.22	1.27	1.64	0.28	1.27	1.27	1.71	1.57	0.22
Sci9	4.33	4.68	0.19	4.50	4.50	1.00	4.36	4.64	4.29	4.71	0.76

Note. S-STEM survey results for all Science items. Significant or trending p-values highlighted in green.

There was a trend for Sci7: "Science will be important to me in my life's work", in the interaction between intervention and group, *F*(1,16) = 1.23, *p* = 0.07. While C1 showed a slight decrease to the post intervention mean, C2 showed an increase to the post intervention mean (C1 pre survey item mean (std. error) = 4.91 (0.28), C1 post survey item mean (std. error) = 4.73 (0.17), C2 pre survey item mean (std. error) = 4.14 (0.35), C2 post survey item mean (std. error) = 4.86 (0.21)). This could indicate that the second iteration of the course increased students' agreement that they see science as important to their future work.

In general, C1 averaged a rating above 4.45 for all positively worded items, and C2 averaged above 4.29. A rating above 4.00 indicates agreement with the statements. Item Sci8 is an opposite statement reading, "I can handle most subjects well, but I cannot do a good job with science." Therefore a lower score indicates a more positive attitude towards the subject of Science. For Sci8 the means for C1 and C2 indicate a disagreement with the statement as seen in Table 8. For the science items there were slight decreases to the post intervention means on Sci1: "I am sure of myself when I do science", and Sci2: "I would consider a career in science". However, all other post intervention item means showed slight positive improvements compared to pre intervention item means for attitudes towards science.

Engineering and Technology

There were nine items related to Engineering and Technology on the S-STEM survey. The intervention did not significantly change student responses on ET2: "If I learn engineering, then I can improve things that people use every day", but there was a slight downward trend for the post intervention mean, $F(1,16) = 3.42$, $p=0.08$, pre survey item mean (std. error) = 4.61 (0.11), post survey item mean (std. error) = 4.31 (0.17). And there was a significant interaction between intervention and group for ET2, $F(1,16) = 0.39$, $p=0.02$. While C1 rated themselves slightly higher on the post intervention than the pre intervention for ET2, C2 rated themselves much lower for post intervention compared to pre intervention (C1 pre survey item mean (std. error) = 4.36 (0.14), C1 post survey item mean (std. error) = 4.46 (0.22), C2 pre survey item mean (std. error) = 4.86 (0.17), C2 post survey item mean (std. error) = 4.29 (0.27)). This could indicate that iteration 2 of the course negatively impacted students' attitudes towards the idea that engineering can improve everyday things for people. This could be due to a number of factors such as more emphasis on science and math in the course, and less emphasis on laboratory activities that explicitly use engineering and technology. Ways to overcome this deficit will be expanded on in the discussion section of this aim.

Table 9

S-STEM Survey Results for All "Engineering and Technology" Items

	Main Effect of Intervention			Main Effect of Group			Intervention X Group				
Item	Pre Survey Mean	Post Survey Mean	Pre vs. Post Sig.	C1 Mean	C2 Mean	C1 vs. C2 Sig.	C1 Pre Survey Mean	C1 Post Survey Mean	C2 Pre Survey Mean	C2 Post Survey Mean	Intervention X Cohort Sig.
ET1	4.47	4.35	0.58	4.32	4.50	0.63	4.36	4.27	4.57	4.43	0.90
ET2	4.61	4.31	0.08	4.41	4.57	0.54	4.36	4.46	4.86	4.29	0.02
ET3	4.23	4.12	0.50	4.14	4.21	0.86	4.18	4.09	4.29	4.14	0.88
ET4	4.47	4.45	0.90	4.27	4.64	0.37	4.36	4.18	4.57	4.71	0.31
ET5	3.86	3.98	0.70	3.77	4.07	0.56	3.73	3.82	4.00	4.14	0.93
ET6	4.35	4.33	0.89	4.32	4.36	0.92	4.27	4.36	4.43	4.29	0.55
ET7	4.77	4.65	0.43	4.77	4.64	0.55	4.82	4.73	4.71	4.57	0.86
ET8	4.60	4.67	0.60	4.91	4.36	0.02	4.91	4.91	4.29	4.43	0.60
ET9	3.93	4.14	0.36	4.14	3.93	0.68	4.00	4.27	3.86	4.00	0.77

Note. S-STEM survey results for all Engineering and Technology items. Significant or trending p-values highlighted in green.

There was a significant difference between C1 and C2 on ET8: "Knowing how to use math and science together will allow me to invent useful things", $F(1,16) = 6.38$, $p = 0.02$. Cohort 1 rated themselves significantly higher on ET8 than C2 (C1 item mean (std. error) = 4.91 (0.13), C2 item mean (std. error) = 4.36 (0.17)). However, while the item mean for C1 remained the same post intervention, there was a slight increase to the item mean for C2 post intervention (C1 pre survey item mean (std. error) = 4.29 (0.24), C2 post survey item mean (std. error) = 4.43

(0.15)). Therefore, while C1 rated themselves higher on ET8, there was some growth shown by C2 post intervention. All ratings for ET8 were above 4.00, indicating that all cohorts agreed with the statement.

Results for the other Engineering and Technology items can be found in Table 9. For C1 there was agreement with all statements (C1 mean 4.14 or above), except for ET5: “Designing products or structures will be important for my future work” with a mean of 3.77. For C2 all ratings for this category were above 4.07, except ET9: “I believe I can be successful in a career in engineering”, with a rating of 3.93. This could indicate a slightly more apathetic view towards engineering by the students in both cohorts.

21st Century Learning

There were 11 items in the 21st Century Learning category of the S-STEM survey. As shown in table 10, there were no significant changes or trends in the results for this category. All means were above 4.00 on the Likert scale for all items in both cohorts and for both the pre and post intervention ratings. This indicates that all students agreed with all statements in the 21st Century Learning category.

The largest increase seen for post intervention was for Cent1: “I am confident I can lead others to accomplish a goal”, $F(1,16) = 2.11$, $p = 0.17$, pre survey item mean (std. error) = 4.46 (0.19), post survey item mean (std. error) = 4.70 (0.11). The largest decrease shown for post intervention was for Cent7: “. I am confident I can make changes when things do not go as planned”, $F(1,16) = 0.82$, $p = 0.38$, pre survey item mean (std. error) = 4.71 (0.12), post survey item mean (std. error) = 4.58 (0.17). C1 rated themselves higher than C2 on every item except Cent8: “I am confident I can set my own learning goals” and C2 had a slight increase to the mean on every item except Cent3: “I am confident I can produce high quality work.” Due to the p-values > 0.08 for all of these items, no significant trends were identified from the results.

Table 10

S-STEM Survey Results for All “21st Century Learning” Items

	Main Effect of Intervention			Main Effect of Group			Intervention Group				
Item	Pre Survey Mean	Post Survey Mean	Pre vs. Post Sig.	C1 Mean	C2 Mean	C1 vs. C2 Sig.	C1 Pre Survey Mean	C1 Post Survey Mean	C2 Pre Survey Mean	C2 Post Survey Mean	Intervention X Cohort Sig.
Cent1	4.46	4.70	0.17	4.73	4.43	0.28	4.64	4.82	4.29	4.57	0.75
Cent2	4.67	4.53	0.49	4.77	4.43	0.17	4.91	4.64	4.43	4.43	0.49
Cent3	4.84	4.81	0.83	4.86	4.79	0.60	4.82	4.91	4.86	4.71	0.33
Cent4	4.75	4.70	0.81	4.86	4.58	0.13	5.00	4.73	4.50	4.67	0.33
Cent5	4.58	4.79	0.27	4.73	4.64	0.69	4.73	4.73	4.43	4.86	0.27
Cent6	4.62	4.70	0.60	4.82	4.50	0.09	4.82	4.82	4.43	4.57	0.60
Cent7	4.71	4.58	0.38	4.86	4.43	0.10	5.00	4.73	4.43	4.43	0.38
Cent8	4.68	4.61	0.69	4.50	4.79	0.30	4.64	4.36	4.71	4.86	0.21
Cent9	4.37	4.42	0.78	4.50	4.29	0.59	4.46	4.55	4.29	4.29	0.78
Cent10	4.39	4.44	0.74	4.68	4.14	0.11	4.64	4.73	4.14	4.14	0.74
Cent11	4.70	4.84	0.33	4.82	4.71	0.50	4.82	4.82	4.57	4.86	0.33

Your Future

There were 12 Your Future items on the S-STEM survey asking participants to indicate their interest in all types of STEM careers or fields of study. There is an upwards trend to the post intervention mean for YF3: Biology and Zoology, $F(1.16) = 3.94)$, $p = 0.07$. This increase becomes significant when looking at the interaction between intervention and group, $F(1,16) = 0.10$, $p = 0.01$. While C1 rated themselves slightly lower on this item post intervention (C1 pre survey item mean (std. error) = 3.00 (0.26), C1 post survey item mean (std. error) = 2.82 (0.29)), C2 rated themselves much higher post intervention (C2 pre survey item mean (std. error) = 2.29 (0.32), C2 post survey item mean (std. error) = 3.29 (0.37)). This could indicate that the increase of Biology based laboratory activities in the second iteration of the course had a positive impact on student attitudes towards choosing a career in Biology.

There is a significant difference to the post intervention mean for YF4: Veterinary Work, $F(1,16) = 9.14$, $p = 0.01$, pre survey item mean (std. error) = 1.93 (0.23), post survey item mean (std. error) = 2.47 (0.19). While both cohorts increased their ratings post intervention, the majority of the shift can be attributed to the change in C2 post intervention when looking at the interaction between intervention and group, $F(1,16) = 0.66$, $p = 0.02$, C1 pre survey item mean (std. error) = 2.00 (0.29), C1 post survey item mean (std. error) = 2.09 (0.24), C2 pre survey item mean (std. error) = 1.86 (0.36), C2 post survey item mean (std. error) = 2.86 (0.30). I cannot attribute this change to any specific revision to the course because I do not identify any particular activity or content that directly related to veterinary work. This may have been influenced by other activities or experiences within SVSM that were outside of the Nanoscale Science course.

Table 11

S-STEM Survey Results for All "Your Future" Items

	Main Effect of Intervention			Main Effect of Group			Intervention X Group				
Item	Pre Survey Mean	Post Survey Mean	Pre vs. Post Sig.	C1 Mean	C2 Mean	C1 vs. C2 Sig.	C1 Pre Survey Mean	C1 Post Survey Mean	C2 Pre Survey Mean	C2 Post Survey Mean	Intervention X Cohort Sig.
YF1	2.75	3.12	0.12	2.86	3.00	0.74	2.64	3.09	2.86	3.14	0.72
YF2	2.58	2.79	0.22	2.73	2.64	0.80	2.73	2.73	2.43	2.86	0.22
YF3	2.64	3.05	0.07	2.91	2.79	0.76	3.00	2.82	2.29	3.29	0.01
YF4	1.93	2.47	0.01	2.05	2.36	0.43	2.00	2.09	1.86	2.86	0.02
YF5	2.60	2.88	0.23	2.77	2.71	0.89	2.64	2.91	2.57	2.86	0.98
YF6	2.88	2.88	1.00	2.91	2.86	0.93	2.91	2.91	2.86	2.86	1.00
YF7	2.14	2.26	0.39	2.18	2.21	0.92	2.27	2.09	2.00	2.43	0.04
YF8	2.68	2.60	0.60	2.64	2.64	0.99	2.64	2.64	2.71	2.57	0.60
YF9	3.25	3.33	0.22	3.36	3.21	0.72	3.36	3.36	3.14	3.29	0.22
YF10	3.16	3.47	0.13	3.70	2.93	0.02	3.60	3.80	2.71	3.14	0.57
YF11	2.86	2.78	0.77	2.64	3.00	0.38	2.55	2.73	3.17	2.83	0.33
YF12	3.28	3.26	0.93	3.18	3.36	0.66	3.27	3.09	3.29	3.43	0.49

Note. S-STEM survey results for all Your Future items. Significant or trending p-values highlighted in green.

There was a significant difference between the cohorts on YF10: Chemistry, $F(1,16) = 0.35$, $p = 0.02$. C1 rated themselves significantly higher than C2 students on their interest in

Chemistry for their future studies or career (C1 item mean (std. error) = 3.70 (0.20), C2 item mean (std. error) = 2.93 (0.24)). Despite this difference between the cohorts, both groups showed a slight increase in interest for Chemistry post intervention as can be seen in Table 11.

In general, all means were above 2.00 for C1 and C2 showing at least mild interest in all STEM related career fields. All post intervention means were slightly higher for all items except for questions YF8: Computer Science, YF11: Energy, and YF12: Engineering. These results can help influence what other experiences and activities can be added to future iterations of the Nanoscale Science course.

About You

There are nine items in the About You category of the S-STEM survey. Items AY1 – 3 use a 3-point Likert scale with answer choices: Not Very Well (1), Ok/Pretty Well (2), and Very Well (3). Items AY4 – 9 use a 3-point Likert scale with answer choices: Yes (3), No (1), and Not Sure (2). There was a trend in the interaction between intervention and group for AY6: "Do you know any adults who work as scientists?", $F(1,16) = 0.70$, $p = 0.07$. While cohort 1 rated themselves higher on AY6 post intervention (C1 pre survey item mean (std. error) = 1.73 (0.28), C1 post survey item mean (std. error) = 2.18 (0.27)), cohort 2 rated themselves lower post intervention (C2 pre survey item mean (std. error) = 2.43 (0.35), C2 post survey item mean (std. error) = 2.14 (0.33)).

Both iterations of the course had opportunities to meet with professors who work in the Nanoscale Science field. These professors gave guest lectures and/or tours of their labs for the cohorts. There is a goal to increase the number of experiences students have with professors on campus in future iterations, and specifically to invite more varied disciplines to speak to the students. These revisions could influence future results for this item on the S-STEM survey for cohorts in the Nanoscale Science course. The overall results for this category are shown in Table 12.

Table 12

S-STEM Survey Results for All "About You" Items

	Main Effect of Intervention			Main Effect of Group			Intervention X Group				
Item	Pre Survey Mean	Post Survey Mean	Pre vs. Post Sig.	C1 Mean	C2 Mean	C1 vs. C2 Sig.	C1 Pre Survey Mean	C1 Post Survey Mean	C2 Pre Survey Mean	C2 Post Survey Mean	Intervention X Cohort Sig.
AY1	2.82	2.91	0.26	2.73	3.00	0.10	2.64	2.82	3.00	3.00	0.26
AY2	2.88	2.93	0.44	2.96	2.86	0.45	2.91	3.00	2.86	2.86	0.44
AY3	2.96	3.00	0.44	2.96	3.00	0.44	2.91	3.00	3.00	3.00	0.44
AY4	2.87	2.96	0.18	2.91	2.92	0.96	2.91	2.91	2.83	3.00	0.18
AY5	2.87	2.96	0.18	2.91	2.92	0.96	2.91	2.91	2.83	3.00	0.18
AY6	2.08	2.16	0.67	1.96	2.29	0.41	1.73	2.18	2.43	2.14	0.07
AY7	2.05	2.26	0.27	1.96	2.36	0.36	1.82	2.09	2.29	2.43	0.73
AY8	1.98	2.02	0.84	2.00	2.00	1.00	1.82	2.18	2.14	1.86	0.11
AY9	1.84	2.02	0.44	2.00	1.86	0.71	1.82	2.18	1.86	1.86	0.44

Note. S-STEM survey results for all About You items. Significant or trending p-values highlighted in green.

Discussion

The students who participated in the SVSM Nanoscale Science course are already highly interested in STEM as a field to study and a potential career path. This creates pre-intervention data that is already reflecting attitudes towards STEM that are near the top of the rating scale for the S-STEM survey. This does not leave much room for growth from the intervention. However, to see students' ratings remain high and raise slightly can be considered a success for the Nanoscale Science course. The intention of the program is not only to try to improve student attitudes towards STEM, but also to not create an experience that discourages students from continuing in STEM fields. From the results of this study, the Nanoscale Science course was successful in maintaining positive attitudes towards STEM in the participants, and in some cases improving their attitudes towards STEM.

One area of improvement that could be a focus for future iterations of the course is in Engineering. Student ratings for the Engineering and Technology category had the largest room for growth compared to the Math and Science categories. Creating more engineering activities in the course could allow for a more unique and impactful experience for the students. While math and science classes are emphasized in their high school curriculum, engineering is not as common a focus. Building some connections to the Engineering departments at UNC Charlotte to bring in a guest lecturer or laboratory tour could be a goal for future Nanoscale Science course iterations.

Not all students completed both the pre and post surveys, which limited data collection from an already small sample size. For future iterations, it would be beneficial to take steps to increase the rate of participation from students to gather accurate results. This could be done by making it an assignment in Canvas to add importance to the survey, or by adding an incentive to completing the surveys. The survey is also quite long, and removing some of the items that are more repetitive could help increase participation rates.

CONCLUSION

The two programs assessed in this dissertation both focus on the establishment of quality STEM education in secondary and post-secondary schools. Gaining understanding of their impact on participants and findings ways to improve their efficacy is a way to work towards that overarching goal.

As the STEM Academy continues its work with faculty members across STEM disciplines, the results of these interviews and focus groups can offer ideas to improve STEM Academy. As explained in the Self-Reflection section of the results, many of the participants said that their teaching philosophy already reflected the goals of the STEM Academy. This indicates that the participants have already bought into the idea of using evidence-based teaching practices and the STEM Academy can sometimes be described as "preaching to the choir". The STEM Academy could try to recruit more instructors that have been resistant or apathetic to trying new practices in their classrooms. This could be done by reaching out to department chairs to ask them to encourage their faculty members to join the STEM Academy. Department leaders would be more likely to encourage the instructors to join if they were aware of the benefits of the STEM Academy and what it had to offer. Sharing the results of these interviews and focus groups will be helpful in recruiting more participants.

Outside of recruitment, some structural changes to the meetings have been suggested by participants. Most examples involve allowing for more time for discussion. In her interview, Makayla expressed being interested in hearing more success stories from the other participants. This would be helpful in motivating the other participants as well as providing them with more ideas for how to implement new evidence-based practices. In his interview, Kalvin expressed wanting more time to discuss the readings that were assigned in between meetings. The readings are thought-provoking, and allowing for more discussion time will help make them more useful to the participants as they are allowed to process the material. In Jon's interview he expressed the need for more timely feedback from the co-leaders of the STEM Academy as well as from the other participants. Having a designated time for feedback as new activities are implemented in courses would be beneficial to both the instructor trying the new practice as well as the other participants who get to hear about the results and share insights.

The SVSM Nanoscale Science course will have its third iteration beginning June 27, 2024. The results of this study have been used to influence changes to the curriculum and instructional design of the course. An emphasis is being put on helping students find an innovative and reasonable project within the first two weeks of the course. This will be facilitated by ordering supplies with specific projects or concepts in mind for students to develop, recruiting new co-instructors, and incorporating more visits to laboratories on campus and guest lecturers by faculty members. There are two new co-instructors, Venky Ranjan and Dan Langdon. Ranjan is a Nanoscale Science Ph.D. candidate who has experience and access to characterization instruments that will allow the students in the third cohort (C3) unique opportunities for research projects and data collection. Langdon is a Biology Ph.D. student who can provide expertise on student research projects in the Biological Sciences, which has been a primary interest for many students in past cohorts. Nanoscale Science is interdisciplinary and recruiting instructors from other STEM disciplines can help broaden the scope and opportunities for the students. Increasing the number of laboratory visits and interactions with professors on campus will help give students perspective on the applications of the BINS and possibilities for future careers. Before a guest lecture, students will be tasked with doing background research on the speaker, which will give them more experience with reading scientific literature and publications to develop questions for the lecture.

While the design of this course is unique to the SVSM program structure, teaching high school students about Nanoscale Science can be incorporated into traditional high school Chemistry and Biology courses on a smaller scale. Pieces of the curriculum developed for this course can be used in high school science classes outside of this program. As is shown in table 1, NCDPI Essential Standards are already related to the Big Ideas of Nanoscale Science, which means adding instruction to include BINS will not deviate from the curriculum in place. Nanoscale Science concepts can be introduced into the high school curriculum through the adoption of a laboratory activity or demonstration such as; in a physics classroom one could recreate the double-slit experiment to observe the duality behavior of light particles (Exploratorium, 2024), in a biology classroom one could grow classroom-safe bacteria and test different methods of killing the bacteria like the use of nanosilver (accessible for classroom use in materials like colloidal silver) (Sotiriou & Pratsinis, 2010), or in a chemistry classroom one could test the efficiency of organic electronics to discover the unique properties of different allotropes of carbon (Kolker, Cook-Chennault, & Kupferberg, 2020).

With the results from the S-STEM survey, it is shown that the SVSM Nanoscale Science course supports positive student attitudes towards STEM. The students maintained high ratings for the items in Mathematics and Science, as well as continued interest in pursuing a variety of STEM related careers or courses of study. With the implementation of evidence-based teaching practices, students were able to learn challenging content while maintaining a positive attitude towards the subject area.

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Appendix A – Interview and Focus Group Transcripts

The following are the transcripts from the interviews and focus groups conducted with the participants from the STEM Academy. The transcripts are in chronological order.

Interview with Georgia 3/30/22 12 pm

Interviewer: I Georgia: G

I: General background. What is your position?

G: I am a full time lecturer in the department of biological sciences.

I: And how many years have you been teaching?

G: Seven.

I: How many years have you participated in the STEM Academy?

G: This is my first, so one year.

I: What courses do you typically teach?

G: I teach ecology, which is BIO 3134. I teach scientific writing, which is BIO 3274. And conservation biology, which is BIO 4244

I: What courses are you focused on in the STEM Academy?

G: Ecology.

I: What are the benefits you have seen from the Academy?

G: I've seen a lot of benefits. I've learned to scaffold my course better during course planning for improved outcomes for my students. I've developed my course and my module level learning objectives. And developed traditional and alternative assessments for each objective. And I think I have improved my overall course alignment, and have added in some new activities and assessments that are really different than what I would have come up with on my own.

I: Do you feel that the academy provided you with the tools necessary to transition face-to-face classes to online?

G: Yes, absolutely.

I: Can you tell me about an example of an evidence-based practice that you have implemented because of the academy?

G: So I have, let's see if I can remember what we talked about last week with evidence based practices. I have incorporated active learning into my course. Even though it is an online course, I think that the STEM Academy has offered some active learning tips that can be applied to online courses.

I: what was the role of the academy in adopting this practice?

G: The role was by providing examples and giving situations in which I might use these active learning methods.

I: did you enjoy the change?

G: Yes, very much.

I: What challenges did you face in implementing this change?

G: So, students can be somewhat resistant to change in class, and especially with active learning they tend to sometimes not think that they want to engage in it. But once they become engaged, I think that it is worth doing the change, and worth practicing something new.

I: have you implemented this change in upper level classes?

G: No.

I: Can you tell me about a second example of an evidence-based practice you have implemented because of the academy?

G: I feel like that the Academy… I think that it has given me a new focus on inclusive teaching that I didn't have before. That I can use to benefit my students.

I: What was the role of the academy in adopting this practice?

G: Really bringing to light what inclusive teaching and learning can mean.

I: How do you like the change? Do you enjoy it?

G: Yes, yes

I: What challenges did you face in implementing this change?

G: I think just the unknown of trying something new was a challenge.

I: have you implemented it in your non-STEM Academy classes?

G: Yes.

I: anything deter you from implementing the desired practices?

G: No.

I: Has the Transforming STEM Teaching and Learning Academy influenced or led you to change your teaching philosophy? How so?

G: Yes, it is really, like I have mentioned before, I think it changed my perspective on inclusive teaching, which has changed my philosophy in just being aware of diversity and equity and inclusion and bringing some of the evidenced based practices around that into my class.

I: Has the Transforming STEM Teaching and Learning Academy enabled you to coordinate with other faculty within your department as well as outside your department

G: Yes, I've really enjoyed the interaction with other faculty members through the STEM Academy. If fact I've really looked forward to these monthly meetings, just to get a chance to talk with faculty outside of my department some who are interested in similar things that I am with pedagogy.

I: What are the benefits gained from coordinating with other sections/instructors?

G: Yeah, I think that building a learning community around STEM courses. I've just really felt a connection with all of the faculty from different disciplines.

I: Were your efforts to transform your course(s) supported and recognized by your department, college, and university? If so, can you explain how? If not, can you explain what would have made you feel supported and recognized?

G: Not yet, but I'm still just in my second semester of STEM Academy.

I: What would have made you feel supported and recognized?

G: Good question. I think just personal recognition from my department chair, just a communication just letting me know that these changes matter. So just some accolades about taking the effort to incorporate these things. I think just hearing from my chair would be very beneficial.

I: Is there anything else you would like to share with us about the Transforming STEM Teaching and Learning Academy?

G: I really liked how supportive the Academy was offering the sessions both online and in person. I found that to be really helpful, that flexibility.

I: Any additional comments about benefits or barriers about implementing the practices?

G: No, not really.

Interview with Kalvin 3/31/22 9 am

Interviewer: I Kalvin: K

I: To begin, I have a few general background questions for you. What is your employment status and rank with the University? Part time/Full time and Tenure track, lecturer, part time, etc.

K: I'm a full-time senior lecturer in the department of geography and Earth Sciences

I: How many years have you been teaching?

K: 16
I: How many years have you participated in the academy?

K: a full year, fall of 2020 and spring of 2021

I: What courses do you typically teach? What courses are you focused on in the Transforming STEM Academy?

K: I teach earth science 1101 which is Introduction to physical geography, I teach meteorology 1102 which is Introduction to meteorology, I teach fundamentals of meteorology which is a 3000 level course, I teach synoptic meteorology and it's corresponding 3 hour lab, and I also teach weather forecasting which is a 3000 level class. I teach her earth science Capstone Course once in a while, or a science 4600. The STEM Academy was earth science 1101, of physical geography course.

I: What are the benefits you have seen from the academy?

K: I think the biggest benefit for me was actually working with other people from other departments and seeing what they do. Especially introductory courses, some of the technology that they used was something that was new to me. And I was able to integrate some of that into my classes and at least that is a plan going forward. I think that was one of the biggest benefits. Because we tend to get in our own circle, it is nice to see other perspectives. Especially across some of the Sciences. That was one of the biggest benefits I thought.

I: Do you feel that the academy provided you with the tools necessary to transition face-to-face classes to online?

K: Yeah again I would stress a lot of the tools that we were introduced to. Not just from the academy but in our subgroups we were working and whatnot. I thought the open dialogue we had about "hey we tried this, or have you seen this". And literally show it on the screen, it was helpful in that sense that you could see things in action that I hadn't seen before. I think that helps make online learning, because we all know online learning is challenging and engagement is a big thing that popped up. And do ways of getting students engaged. I think that again was one of the biggest benefits.

I: Can you tell me about an example of an evidence-based practice that you have implemented because of the academy?
K: I've actually done this in some of our upper division classes I haven't taught or science 1101 since I was in the academy. I've tried to integrate real time in real world examples, it's really easy to do in meteorology because weather is happening all the time. So we would take current examples in reality right now and study that in class. So studying kind of here is what's happening, we take the theory and apply it to real time examples making it very relevant to the students. I think that was, that's been super beneficial.

I: What was the role of the academy in adopting this practice?

K: I think the academy was good in that it set us up in the beginning to show us learning outcomes the goals of the classes, and then how to achieve those goals. I gave us a little bit more structure. And what I really liked was in our case for earth science we have a broad range of faculty that teach this from part-time to PhD students, so these practices could be shared across all of those faculty that teach this course. And that way it gives students a similar 1) learning objectives and learning outcomes, and 2) a similar style of teaching and that course whether it's evidence-based or project based. And it gives people more options on how to do that, and we disseminate that amongst the faculty.

I: How do you like the change? Do you enjoy it?

K: I did especially in the Summer where I do teach fully online. That subsequent summer after the academy I was able to try some of these new technologies. Some of them worked great others were more trial and error. It was nice to hear people's examples and be able to let some of that stuff.

I: What challenges did you face in implementing this change?

K: I think the biggest challenge is, we were working our own department subgroup, and I felt like change only happens as fast as the group was willing to change going forward. I think my biggest struggle is I'm very motivated,. I want to get something done right now right now right now and not everybody is that way. So I think one of the biggest challenges was, was saying okay here's what we need to do and actually implementing it across all of our courses and getting everyone on board. That was a bit of a challenge for sure.

I: Have you implemented this change in upper-level classes?

K: Yes, so I've taken more of the tech and the project-based learning, the experiential learning, those kinds of things. Not necessarily a flipped classroom, but those kinds of teaching techniques and I've definitely use those in my upper division classes for sure.

I: Can you tell me about a second example of an evidence-based practice you have implemented because of the academy?

K: In my weather forecasting class this semester is a great example of I've been giving them more pre-recorded material and work to do outside of class and in the class we are much more focused on actually applying the principles. So we I have turned the class more into a lab almost when we meet, and then the students have this expectation that when they come in and after doing these modules that I've created ahead of time, then we can focus on applying the principles that we've learned about. So that's honestly been a great success. The students have absolutely loved it this semester. Especially in a day like today, there's severe weather, so that's all we focused on yesterday in class, not lecture we just focused on forecasting and working for the material. I really enjoy this model a lot now.

I: What was the role of the academy in adopting this practice?

K: I think for me it was hearing how others have implemented similar practices in their classes to success. It's one thing to read about something, but it's another to have a colleague say "listen, I've done this and it's made a world of difference." Especially with online stuff hearing about the different technologies that folks were using, and how to go about implementing them. That's one. And then 2) I thought the other benefit of the academy was really restructuring our science course. Because the goal on our team was to restructure this course so that was uniformly taught across all of the sections because there's like 12 sections of the class with different instructions and varying levels of what students are getting from this class. So there was really an effort to try to streamline that. So the first semester of the academy that's what we really focused on is revamping that class in terms of the horizontal learning out comes across the sections. But then also vertical, how that class is in the prerequisite to a multitude of classes in the department. So it was more of a horizontal and vertical integration I would say so.

I: How do you like the change? Do you enjoy it?

K: I did. It's been something I want to do for years and this was something of an avenue to allow us. And it pushed us in that direction. Because once again it's easy for me to make these changes, but to get eight other faculty on board to make these changes. Now I can say the STEM Academy made me do this, so I can use it as a tool to make some change.

I: What challenges did you face in implementing this change?

K: I think the biggest challenge as I mentioned was just trying to get full buy-in from this. Again I think the difficulty for us in our department is a lot of these classes are taught by part-time instructors and PhD students. And those instructions are changing from semester to semester. So trying to create very similar styles of material. We've been toying with the idea of actually creating some modules for some faculty that's just uniform, that way students we know are getting this material across. So I think that's the biggest struggle as a class like this with so many instructors, is trying to make it what we want it to be.

I: Have you implemented this change in your non-STEM Academy classes?

K: Yeah like I mentioned my upper division meteorology classes, some of the technology that was introduced I've redone my SLOs (student learning objectives), because I realized after the

STEM Academy how poorly written they were. So I've done that and like I already mentioned I've already done some flipped classroom stuff and more experiential learning and most of my upper division classes in the fall and spring.

I: Did anything deter you from completing or implementing desired practices? How can the Academy help remove these barriers?

K: I guess having our department chair and associate chair, getting them to have more buy-in. I think what happened was a couple years ago there was a call that said the STEM Academy is forming, we're looking for classes. Two of my colleagues and I volunteered to do it and we did it. But then it just kind of wasn't really put out there too the departments as much I don't think. Our department chair and associate chair just didn't, they knew we were doing something but they just didn't have a lot of influence on our part-time faculty and other folks that are teaching these classes. And I've talked to my department chair about this over the summer right before classes started in August, having a three or four hour workshop with our part-time folks and PhD students. We actually did this with our graduate students last summer, it was great. Basically how to teach these classes, what are the expectations, challenges you're going to face in these classes. We did this for the grad students, we had an orientation day. And we're toying with the idea for doing it with our part-time instructors this summer, we would introduce this to all of our intro courses. So I guess that's kind of a solution to perhaps pushed departments more for adopting some of these changes.

I: Has the Transforming STEM Teaching and Learning Academy influenced or led you to change your teaching philosophy? How so?

K: Actually yes, I would say. It's pushed me away from standard lecture based classes. I mean I have labs attached to some of my classes, so that's kind of a mix. But again this semester in particular my one upper division course I have completely redone how I do this class because of the STEM Academy. And hearing examples of folks doing it this way. So I've definitely been happy with how it's been implemented and the changes that have occurred.

I: Has the Transforming STEM Teaching and Learning Academy enabled you to coordinate with other faculty within your department as well as outside your department?

K: Yes, So obviously we became in as a group so we were always coordinating amongst ourselves. So that was nice. But what I found really helpful was, like I mentioned, we broke into subgroups And we had discussions and then we would meet back with the main group. And in those discussions it was fun because everyone's just you know talking about, especially the first year I did it or the first semester because we were right in the middle of online and everybody was sharing about what we can do with this “Have you tried that.” So a lot of just sharing of ideas and things we found that were effective. We got to put videos together. We made little components. So it was a fun experience I thought.

I: Were your efforts to transform your course(s) supported and recognized by your department, college, and university? If so, can you explain how? If not, can you explain what would have made you feel supported and recognized?

K: Yeah our department chair has been a huge advocate for this. I think it would be better if we had, and maybe it's up to us to keep her and our associate chair more informed, as we're going through this process. because it seemed like we started the STEM Academy and then nothing was heard about it for a year basically until the next STEM Academy came out. So I think that would be beneficial. I mean I've talked to some upper administrative folks who are very aware of the program and are very supportive of it, but I haven't personally seen any working of the upper divisions. I've just seen our department. Especially since I've been promoting having a training this summer for a part-time faculty, I know there's a lot of support for that. And I know a couple of our instructors are still in the same Academy this year.

I: Is there anything else you would like to share with us about the Transforming STEM Teaching and Learning Academy? Do you have any additional opinions regarding the benefits or barriers to implementing some of the evidence-based practices?

K: I thought it was well organized. I guess my only thing that I found, I don't want to say not helpful, but whenever we are assigned a large amount of reading and then we had to fill out, it wasn't an exam but basically questions about the reading. I wish you would have discussed some of those things a bit more. I felt more like hey read this and fill out the questionnaire and now you are kind of an expert on this. So I wish we could have talked about some of more of the teaching practices that we had read about, and course design that we had read about a little bit more. Even in smaller breakout groups, or something like that would probably be one of my big suggestions., because I felt like I did a lot of reading, which I could do that anywhere, I would prefer to talk about it and discuss it.

Interview with Makayla 4/1/22 11:30am

Interviewer: I Makayla: M

I: What is your employment status and rank with the University? Part time/Full time and Tenure track, lecturer, part time, etc.

M: I'm an adjunct faculty

I: Within what department?

M: Chemistry

I: How many years have you been teaching?

M: Three and a half years

I: How many years have you participated in the academy?
M: just this year

I: What courses do you typically teach? What courses are you focused on in the Transforming STEM Academy?

M: I teach Gen Chem 2, that's my lecture. My labs are Gen Chem 1. My focus for the STEM Academy was Gen Chem 2.

I: What are the benefits you have seen from the academy?

M: So I've been able to find more ways to assess my students. And I'm talking more about when we talked about alternative assessments. It was quite recent but I already implemented in this semester some assessments from STEM Academy the things that we discussed last semester. And now in this semester I've been putting more alternative assessments, towards the end of the semester to see how my students are performing. At the end of this semester there's a chapter that we, the professors and I, don't have much time to go over it, so we just have one or two lectures, and the assessment of the materials only in the final exam. So I'm trying to bring kind of a sort of project, they will have about a week to do it, it's short but it will go over a big part of the chapter. So it'll be another assessment besides the final exam. They'll have to go over it in order to get to the final so it will make them study more, because from feedback from my students I see that they are looking for homework or things that would make them go over the material that they have to go over. And I'm looking at other ones that I'm putting in also. I got more guidance on how to write my objectives, or even to have them in my head when I'm presenting. So I'm doing baby steps. I can't implement everything but I took notes, and even during the meetings I have ideas and I jot them down. And later I bring an assessment or a discussion to my students. Also when we were discussing oh you should do this or do that, it was reinforcing things that I was already doing. So I felt like, "oh I'm doing a good thing, since I already have this in my lecture", so I'm glad that's reinforced. So for me I think it was a way to expand the way I present. It was telling me what I'm doing good or not. And it brings a different or additional view on how to have my lecture and have to present, and have to assess it, and how to connect with my students. For me it was beneficial.

I: Do you feel that the academy provided you with the tools necessary to transition face-to-face classes to online?

M: Well the Academy I started after, so for me it was during the online, so I was already having class online. And now we're moving back to probably face-to-face. But being online it was more challenging than face-to-face, and I had said that we need more ways to assess. Because when I was face to face I was having in class quizzes, which are not an option or I don't want to use the online time to do them. And it takes time to upload, so I can't do that during a lecture online. But with the alternative assessments I can introduce some kind of a quiz. I introduced a pre-class quiz before we started a new chapter, to see if their knowledge from the previous course matches what we will use in this chapter. And they have two attempts so they know what they should look up after the first attempt and what they did wrong, so they can go back and redo it. So it didn't help me to do that, but it helped me to better my online course.

I: Can you tell me about an example of an evidence-based practice that you have implemented because of the academy?
(examples given from previous questions)

I: What was the role of the academy in adopting this practice?

M: Well it opened my mind on how to do it. I brought the idea of you can do this. You can ask students a shorter part of the chapter or of the class, and you don't have to make it an exam, or a project or a bigger quiz. Just a little bit and then you can grade it for them and they have time and it's not a homework. So it's something that I can implement, but I wasn't aware that I could do it before. Or not that I wasn't aware I didn't have the reassurance that I should. It showed me I could have something in my course that I didn't have before.

I: How do you like the change? Do you enjoy it?

M: Yes. Yes and I think my students really enjoyed it. So we'll see, because of the end of the semester I have kind of a course feedback. And I will put this question in, “did you like the additions did you like the pre-class quizzes?” So I'll have these specific questions that I need them to answer, and we'll see what they say. If they say they hated them then we'll see if we need to take them out. I have to see I don't know.

I: What challenges did you face in implementing this change?

M: It was time. I need the time to think about it I need the time to introduce it in my course. How to integrate it seamlessly in my course in the middle of a semester? That was my challenge because it is always a constraint for time. I also had to think of what I am missing what do I want to introduce without them having to miss it.

I: Did anything deter you from completing or implementing desired practices?
M: No, the thing is I said was time. And because we're in the middle of a semester how to do it, to seamlessly do it. Because between semesters I had more time to think of where I could add things and how I could do things. In the middle of the semester it is harder, because you already have a structure for your course, and to introduce something else it's a little bit harder. But that was the only thing, how to introduce it into my already made structure.

I: How can the Academy help remove these barriers?

M: Give us some time and come to us for some feedback after a semester to see if we implemented in how we did. Because I was looking at the blueprint recently, and on the back it has a reflection and it says "a reflective piece should be completed after implementation, what went well, what needs Improvement, what support do you need". And I am just in the process of implementing it, so I don't know how it will be received. I don't know how to improve it at this point. So you're asking me some stuff that I can't answer at this point. So you could ask us what we plan to implement in a semester or two, and then later ask us how it went. But at the end of the semester right now I'm focusing on teaching, and so are my students and I'm not asking them how it went. At the end I'll ask them how it went.

I: Has the Transforming STEM Teaching and Learning Academy influenced or led you to change your teaching philosophy? How so?

M: No, as I said it just helped to reinforce my ideas of how I was teaching. Telling me you're doing a good job with what you're doing. And helping me introduce new things. It didn't change my way of teaching. And the thing is that I was always open for my students, and even receive letters from my students saying, "oh we used to hate chemistry before you were our teacher, and now we love it." So I usually use their feedback. But there are some things that are done behind the scenes that students can't help with. And that's where STEM Academy stepped in and helped me. They said, "yes you can do this, you can expand in this way, you can write your objectives in a different way or I'm more structured way sometimes." So that's where it helped.

I: Has the Transforming STEM Teaching and Learning Academy enabled you to coordinate with other faculty within your department as well as outside your department?

M: When I joined we joined as a group. It's three of us and we're teaching the same course. And we're trying to make our course better, In the sense that if somebody knew joins And has to teach this course they won't start from scratch. They would have a place to go for questions like what questions to ask on an exam, Or what are the objectives of the course. So we are trying to improve our course, and STEM Academy was a resource to improve our course.

I: Were your efforts to transform your course(s) supported and recognized by your department, college, and university? If so, can you explain how? If not, can you explain what would have made you feel supported and recognized?

M: Well we got approval to participate, but I'm not sure... the thing is also I'm an adjunct so it's hard to see what happens, if it is discussed at department meetings or not. So I cannot answer that.
I: Can you explain what would have made you feel supported and recognized?

M: I don't know, maybe a letter from the department chair saying, "thank you for participating and trying to improve your teaching and expand your knowledge". I don't know maybe something like that. Other people mention some kind of monetary thing, maybe that would be a way to do it. Otherwise I don't know how else. I mean I'm doing this for me and my students, not the department. It will benefit the department because the level of my teaching will be better and my students will have a better experience. But I wasn't looking for something from the department to make me do this.

I: Is there anything else you would like to share with us about the Transforming STEM Teaching and Learning Academy? Do you have any additional opinions regarding the benefits or barriers to implementing some of the evidence-based practices?

M: I would like to see in STEM Academy maybe some people who could share successes. Or people sharing how they used in the past and what they used it for. So I use them Academy for my assessments and to crystallize my objectives, but what did other people use it for? What did it help them with? So when I joined I joined so that we could find ways to improve our course, and I learned many other things. So I want to know why other people joined it because I did not know what to expect.

Interview with Jasmine 4-1-22 3 pm

Interviewer: I Jasmine: J

I: What is your employment status and rank with the University? Part time/Full time and Tenure track, lecturer, part time, etc.

J: Assistant professor, full time

I: Within what department?

J: Physics

I: How many years have you been teaching?

J: About 20 years

I: How many years have you participated in the academy?

J: I have participated one year

I: What courses do you typically teach? What courses are you focused on in the Transforming STEM Academy?

J: Physics here at UNC Charlotte. Physics and astronomy. For the STEM Academy I was focused on physics but also on waves and Optics.

I: What are the benefits you have seen from the academy?

J: In general it broaden up my vision of teaching. It gave me many resources I wasn't aware of. For example from very simple websites to articles on pedagogy to understanding my problems from a completely different perspective. The other thing that benefited me a lot there was one specific exercise with the rubrics that helped me plan my class ahead of time that was very useful. Like really making me aware of how I was using my time effectively, how much time I was using myself to lecture, how much time it was using for my students to participate and interacting with each other. Also it gave me the chance to meet my colleagues and learn from their own experiences and what they were teaching and using, like the type of tools they used. And it also of course helped in a sense of belonging. Knowing that there is a community and we are all struggling with teaching. It also gave me the opportunity to attend a conference that really opened my eyes to many things, ways of teaching, things that I would be skittish by myself to do. Because I thought maybe that was not a good approach. But then finding that others are already implementing this and that it was actually working out well, or what not to do. But also the chance to be a part of a community with other teachers and professors. I have multiple examples that I could say but in general all very positive. All of them were very positive.

I: Do you feel that the academy provided you with the tools necessary to transition face-to-face classes to online?
J: I attended before the pandemic so

I: Can you tell me about an example of an evidence-based practice that you have implemented because of the academy?

J: One of the things the academy asked us to do is make one small change. And what I did is try and add hands on activities to my Waves and Optics class to bring them to the lab so that they can actually to deal with light and lenses and see the practice of what we were learning in theory. I also added some simulations to be part of a holistic way of learning the theory - the simulation and the practice. They use a lot of feedback not only from Kathy and Tonya, but also from another professor from computer science from the academy. Those are really great ideas that helped me to evaluate how it was working, what was not working, why were things not working and hands-on activities in the simulation.

I: What was the role of the academy in adopting this practice?

J: So first of all they triggered the thought of what can I do and Implement myself. I had to think of how can I promote learning in a more active way. They helped me first of all framing it from the very beginning and the very end when I presented my results. They gave me feedback on the way, and by the time I presented my results they gave me feedback on how to improve it further.

I: How do you like the change? Do you enjoy it?

J: I love it. I still keep it as part of my class whenever I teach. I like to keep up in any way I can something like this. I always believed in hands-on activities. I just didn't know the implementation, what do I have to take into account while doing it, that was the big contribution from the STEM Academy.

I: What challenges did you face in implementing this change?

J: First of all having the space. What's the biggest challenge for me the Practical implementation. One thing that did not work particularly when I implemented it, I did not make students aware of what they would get by doing this stimulation, so they couldn't get an appreciation of why it was important.

I: Have you implemented this change in upper-level classes?

J: That was the higher level that I had by then.

I: Can you tell me about a second example of an evidence-based practice you have implemented because of the academy?

J: It was so many years ago, it's hard to think for examples. But what I remember for example is some tools that I used. At first I was using it for competition, Kahoot, but then I switched to Poll Everywhere so I didn't have to pay for it.

I: What was the role of the academy in adopting this practice?

J: It was shared by members of the academy. The STEM Academy was asking for everybody to share different resources they were using. So this was one of the resources. They also shared some sort of website where you can pick research projects were different subjects. For two weeks were we all had to share something.

I: How do you like the change? Do you enjoy it?

J: Yeah I liked it very much. Poll Everywhere is still really helping with student participation.

I: What challenges did you face in implementing this change?

J: Well Kahoot you have to pay for Kahoot. So that is the biggest challenge, it is really fun but you have to pay for it. But Poll Everywhere, challenges because there are resources from the University that we can use to learn how to use them as well.

I: Have you implemented this change in your non-STEM Academy classes?

J: I use it in all the classes.

I: Did anything deter you from completing or implementing desired practices?

J: At the very end there was a problem that I had to teach a class that the whole scheme of how they were teaching the class had to change completely. I was teaching my own class and now I had to teach a team, and I was not a teacher anymore I was a facilitator of problem solvers. So what we were working on in the STEM Academy now had to be done by one person as part of a team and it got very complicated. And not all of us on the team were part of STEM Academy.

I: How can the Academy help remove these barriers?

J: The problem was don't really for the STEM Academy it was that the class had to change quickly, the way we were teaching it. So we were planning as individual teachers but then we had to work as team teachers. And the next year they started a different STEM Academy that worked with team teaching, but I had to take another class and I would have loved to participate.

I: So they did address it but not when you could attend?

J: Yes.

I: Has the Transforming STEM Teaching and Learning Academy influenced or led you to change your teaching philosophy? How so?

J: No my teaching philosophy remains the same.

I: Has the Transforming STEM Teaching and Learning Academy enabled you to coordinate with other faculty within your department as well as outside your department?

J: Yes.

I: Were your efforts to transform your course(s) supported and recognized by your department, college, and university? If so, can you explain how? If not, can you explain what would have made you feel supported and recognized?
J: Yes I was promoted.

I: Is there anything else you would like to share with us about the Transforming STEM Teaching and Learning Academy? Do you have any additional opinions regarding the benefits or barriers to implementing some of the evidence-based practices?

J: I think Kathy and Tonya are doing important work but also they're doing a really good job and helping to create a more cohesive and inclusive environment as well between stem fields. If I were able to join the academy again I would do it.

Interview with Jon 4/4/22 11:30am

Interviewer: I Jon: J

I: What is your employment status and rank with the University? Part time/Full time and Tenure track, lecturer, part time, etc.

J: I'm a full-time faculty member my employment status is I'm a professor of teaching. That is my title. Non-tenure track it's a lecturer.

I: Within what department?

J: Mathematics and statistics

I: How many years have you been teaching?

J: 20 years

I: How many years have you participated in the academy?

J: Since the inception I was one of the original members with Kathy and Tonya. I guess four or five years ago, I can't even remember way first started. We did the top 40 Academy and from that we sort of branched off into the STEM Academy. So I think it's been about 4 years as before the Covid pandemic, and we kinda had to go through the wave of that problem and stuff.

I: What courses do you typically teach? What courses are you focused on in the Transforming STEM Academy?

J: I'm a jack of all trades I do whatever the math department asked me to teach. Anything from math and statistics, Calc one, Calc two, Calc three, differential equations, linear algebra, graduate level classes as well. However for the STEM Academy purposes my focus has been on Calculus 1 and Calculus 2.

I: What are the benefits you have seen from the academy?

J: A lot. The first benefit is it's a wonderful time for the STEM professors to get together to communicate. I don't get to really see these guys except for if it's at somebody's retirement party or whatever. We do work together but we're always teaching, we're on opposite ends of the campus or whatever the case may be. It's a time that we get together and actually talk shop, the things they're doing that's working, the things they're doing that's not working, the things I'm doing that's working, the things I'm doing that's not working. And we get to compare a lot of good ideas and bad ideas. That number one is working outside of our department. In our department we do that all the time. Outside the department, me working with the physics department, the Chemistry Department, the Biology Department, the Engineering Department, seeing what they're doing that I can actually bring back to my class. I do hear from my students on what they're doing, but I don't get to actually interact with them. Number one that has been immensely important. And then looking at some of the ideas of active learning, and what other folks are doing and how they're doing it, and how we can Implement that within our subject matter, whether it be statistics or calculus or whatever the case may be, that's been also incredibly important. Because some things work and some things don't work. Before the STEM Academy we used to do some work that was more general across all curriculum, and that was kind of frustrating because we had these folks that were in the liberal studies program bringing up ideas that they're doing in classrooms and having chats, and we can't do that we don't have time to do that. There are some things they do that there is no feasible way for us to implement, it doesn't work with our curriculum, our context, for the problems we're doing or what we're trying to achieve with our students. So it became frustrating that I would sit in on these talks and stuff and I had nothing really to participate with because there is no way that I could actually utilize anything that they were doing because it was more for liberal studies or whatever they were teaching. But getting together with just STEM folks, we all have that same niche, we have that same style students, and we have that difficulty of trying to get that material across. It was so great to be able to communicate with them.

I: Do you feel that the academy provided you with the tools necessary to transition face-to-face classes to online?

J: Yes I mean they really did help out. Luckily for us there are a lot of things that were in place. One of the things that the STEM Academy encouraged or making videos we were utilizing videos even before the pandemic. But once the pandemic hit the math department came to me and wanted to know what do we have in place if we have to not just completely shut down but we don't want our students to stop. And fortunately we had a bunch of lecture videos that we had done and I had worked on, so we had a very quick go-to, and we created a switch within like 2 days. That we were able to convert over. And the STEM Academy kind of gave us that idea years ago and we were working with it when the pandemic hit so they were very helpful and sitting a lot of this stuff up. And it was more seamless than other departments had in terms of the transition from traditional face-to-face to online during the pandemic and stuff.

I: Can you tell me about an example of an evidence-based practice that you have implemented because of the academy?

J: Yeah we do a lot of learning activities is what they're now called. They were projects before we rename them to thanks to the STEM Academy. And that was basically allowing 1) students to come up with their own questions types, or we would implement a particular parameter and open-ended questions that would allow the students to work in groups and helping to help manage those large sections that always has a problem in terms of putting them into groups and having them work together to formulate solutions and having them work back and forth within the groups to communicate well. And thanks to having preceptors or UTAs or TAs in my classroom, they could go around and actually help group to group. I've got several examples of optimization related rates, I can give you all kinds of calculus stuff we did. It's been very helpful and very insightful too to see students just, you can always tell the ones that are really top-notch that are on their game that actually know what to do, maybe they have a question. Versus some of the students that just sat there because they have no idea where to start, because they haven't been doing the homework, because they haven't been keeping up. So hopefully it showed them, I really went out of my way to make sure it showed them, this is your fault because you're not keeping up with the material where we're at. This is what we're doing, and this is what happens when you don't keep up, and you don't know what to do and you're just leaving it blank and waiting on somebody else. So trying to get them back involved in what they need and stuff like that is a real motivator. But also, that's more of what we want, and I try to communicate that to my students whenever we're teaching a learning activity, is that you're going to be put on these projects sometimes, not just your Junior and Senior projects and stuff like that, but when you're actually working out in the field and you're working on something or other and you've got a problem, “this is a scenario these are your parameters, what's the solution?” This is what we do with science. We got to find the solution to the problem. We got a formulated solution we have to explain it to others. And that's what I want you guys to do. So it's very well-rounded it's allowed us to reach out, and kind of show students even if they're in a 1,000 level class of where you're going with this stuff. So it's multifaceted how it's really helped.

I: What was the role of the academy in adopting this practice?

J: Well, number one we went from traditional lecture, lecture, lecture, to changing up our lecture. And we did it with what we called small changes, and it was brilliant. You just can't turn on a dime with this stuff. We got things in place, we still have to do lecture I mean that's just part of what we're covering material like that. But how we lecture, really the small changes, you know putting in a learning activity here, changing the way that I lecture such that it's more interactive with the students, and more of open-ended style questions while I'm trying to get across... And again it started with the ideas we got from the academy we did it was small changes slowly over the semester. It was gradual and that was the best way to do it. You can't just go, " we want you to redesign calculus how you teach it." That's not going to work. No Professor is ever going to join any stuff like that. The small change mindset was brilliant.

I: How do you like the change? Do you enjoy it?

J: Yes. Yes they were incredibly helpful. It was also very insightful for me in good ways and bad ways. It was insightful to show me mid between tests what the students know and what they don't know, and why they're not keeping up as we mentioned before. And how it also kind of forces them to keep up because if they want to participate and actually get a decent grade out of it because also these learning activities we have to put some sort of grade or number with them otherwise they don't do them. They'll just sit there and twiddle their thumbs. You got to make it worth their while. So having those things implemented has been a real help and real eye-opening experience to see what they knew and don't know so that I can actually go back over what they don't know quickly but one more time as we must keep up with the syllabus and keep up with the material we have to cover.

I: What challenges did you face in implementing this change?

J: Where are the biggest ones was a large classes. And that's still difficult. The STEM Academy taught us and showed us ways of working around it, but there's still this idea but it depends on the classroom you get. So how are the desks laid out, if you got the little seats with a little flap over desk and try to put these guys in groups, versus the rows of desks. You know the classroom is really important, and we worked around that but still there's classrooms that are better than others for trying to put them in groups. Especially if you've got 120, 150 students plus in your classroom and stuff like that doing these activities. And also the STEM Academy in their resources and stuff like that allowed us to have more TAs and stuff with these large classes to allow us to be able to when we do these learning activities at least having more boots on the ground being able to go from group to group to group as they're working on it. Making sure they're on task, if they have any questions they can answer them quickly, as we move through the classroom. That's still one of the things that is still difficult, because again it really depends on the layout of the classroom. Not just the class size and stuff.

I: Have you implemented this change in upper-level classes?

J: Yes I have. For example linear algebra putting them into smaller groups. The thing about upper level classes is they're not as large. In an upper level class that I would have at most 60 students in a linear algebra class, it's not like the 120 plus. And then it depends on the level, like my graduate level classes. Always done something like that similarly.

I: Can you tell me about a second example of an evidence-based practice you have implemented because of the academy?

J: We've done lots of learning activities, the main thing are the small changes that we've implemented. So outside the classroom not just inside the classroom even wanted projects. Evidentiary projects, calculator projects, working with volume rotation or something like that. We've done that and got more towards implementing more group work inside and outside the classroom. Those learning activities are kind of design for in-class activities, but there's also been quite a few of the projects that we're doing outside of the classroom and creating a scenario where they're going to write up the proper problem and solution format of why the answer is what it is. We've done a lot more with the projects and the projects are more outside of the classroom.

I: What was the role of the academy in adopting this practice?

J: Again it was the idea of more of that group work. Having the students kind of work together, that peer learning aspect that they're trying to have us also implement with the idea of creating problems where they actually get to see the mathematics actually working to formulate solutions. Also that mindset of turning a question, a problem in words, into a picture, a physical object a thing they can get their hands on, creating variables of what's unknown, what's known, coming up of what we call constraints, coming up with the objectives. The STEM Academy helped create that mindset and that format that the students are learning in, that will continue to follow them through Calc 1, Calc 2, Calc 3, up through their engineering, or chemistry, or biology, or whatever program they happen to be in. So what are we trying to do, what do we know, what do we not know, so we're creating a map and we're trying to come up with equation half of all of this stuff.

I: How do you like the change? Do you enjoy it?

J: Oh yeah absolutely. And more importantly I think the students enjoyed it. Whether I enjoyed it or not doesn't really matter next semester is another semester and I'll try again, but my students enjoying it and the more they enjoy the material the more time they're going to spend on it then the better I like it because the better they're going to do on the test and it makes me look good.. It's a plus all the way down the line. I would say it's the idea of getting them to want to spend more time on the material.

I: What challenges did you face in implementing this change?

J: Where's the large classes has always been an issue on things like that to get it graded. So one of the things we've done to help grade it is we've created these templates on canvas where we actually have them input their Solutions on canvas to make it a canvas style quiz. So we've utilized our canvas style site and that took a lot of time and effort to actually take a project and input it as a canvas quiz because canvas is just not a real mathematical system, it's actually quite awful with that. So we had to create ways of actually getting canvas to read math, the things we had to out think and teach our students how to implement to get their answers read correctly by the system. But again that's something our students need to know as a progressing through the 21st century with the computer-based knowledge systems that we have most of the time.

I: Have you implemented this change in your non-STEM Academy classes?

J: With the projects, well yes and no. We do projects but no I don't do them on canvas. The smaller classes they just turn in the projects which is fine.

I: Did anything deter you from completing or implementing desired practices?

J: No not really deterred. You know what's going from one semester to the next, and where you are. You know working with the STEM Academy for a project and we're trying to make it the best we can, of course one thing they teach with the STEM Academy and as a professor all together is we know what the answer is but what kind of garbage are students going to come up with. Think about what are they going to do bad on this problem and come up with a really wrong answer, and we need to out think that to guide them right back into try looking at this way instead. The problems that really occurred were I've been working on a project and STEM Academy and by the time I got it ready I'd already moved past that material in my class. So I guess this will be used next semester by the time I get to implement it. So I really didn't have any valuable feedback on how well the project went until the following semester. I don't really consider that a problem but if they figure out a way for more instant feedback because my feedback wasn't always so quick because I had to wait to the following semester to implement this project that we were just working on.

I: How can the Academy help remove these barriers?

J: Make us do the projects earlier? No not really I have no idea. It's not really the STEM Academy's fault, it's just the nature that we're working on these projects while we're also teaching in the semester is going along.

I: Has the Transforming STEM Teaching and Learning Academy influenced or led you to change your teaching philosophy? How so?

J: Yes it's helped me change my teaching philosophy in terms of other ways that I can... My teaching philosophy is help out as many people as I can with the material at hand and present it in such a way that they can digest it. It has allowed me to present material in different ways the different types of people with different types of learning styles can actually latch onto a little bit better. And in that way it really has improved my teaching philosophy in my teaching styles. In terms of my classic philosophy of teaching, and now I probably do mention more about how important Active Learning is, but it really has allowed me to help out more people especially with different types of learning styles versus the classic lecture go home study work problems write problems working in class. I do more open-ended style questions, more things that allow them to think outside the box. Again the idea of you know make a plan, find a solution in room with it. And then more importantly after you come up with the solution, what does it mean? Always ask the students what does it mean. Keep reading that to the students as they're working these problems. Don't just tell him the answer is three. Three what? What does it mean? In that sense it really has broaden and expanded my teaching philosophy to be able to help out even more students with different types of learning styles.

I: Has the Transforming STEM Teaching and Learning Academy enabled you to coordinate with other faculty within your department as well as outside your department?

J: Yes. Number one we mentioned that before about outside the department also within the department. You know, if you look at the type of people who attend the STEM Academy sithin the mathematics Department is the same usual suspects. Because these are our top typically instructors. But we take what we learned and STEM Academy and we also show and work together with our other faculty members that didn't attend the STEM Academy, Are part-time faculty, our graduate students. Especially in things like Calc 1, Calc 2 we're doing something called tight coordination. We were coordinating before and that's allowed us to kind of bring these people in. But under the new implementation of tight coordination, we are actually requiring our instructors to do these models within their classes. We want them to do these projects, we want them to actually use these learning activities and stuff like that. It's not optional. You have to do it because it really is valuable. For a faculty who did not attend this, and more importantly for our part-time faculty and graduate students as well.

I: Were your efforts to transform your course(s) supported and recognized by your department, college, and university? If so, can you explain how? If not, can you explain what would have made you feel supported and recognized?

J: In the beginning not as much, but within recent years especially just before and during the pandemic the shift was very noticeable. In that sense absolutely yes. We had a real sense in focusing on education and teaching during and actually just before but especially during the pandemic. We have really been supported by our department a great deal with implementing these things and supporting us, getting us all to do group work and tight coordination. It is together with faculty who are all teaching the same subject matter and discuss best practices and putting in these learning activities and these projects and things like that absolutely yes.
I: Is there anything else you would like to share with us about the Transforming STEM Teaching and Learning Academy? Do you have any additional opinions regarding the benefits or barriers to implementing some of the evidence-based practices?

J: It has been a real eye-opening experience. It is multifaceted how great the STEM Academy was. Especially having the ability to work outside of our Department Of Reach Out to these other departments and seeing what they're doing firsthand. Usually what I get is for my students and they tell me what they're doing in their other classes, but first hand from the other instructors themselves. We hear from them on things that they tried to do and this thing worked and this thing did not work. So we looked at things that literally did not work and that's also learning about how to fix it. All in all the STEM Academy has been superb. I have thoroughly enjoyed it. Also since the pandemic one of the other issues as always been especially with us teaching and all these different avenues that we go into like committees and other things that we have to attend, sometimes attending the STEM Academy has been tough to make but having it online has been really helpful in being able to join in. But just like my students I enjoyed the zoom aspect of it but being completely and totally online was not what I wanted. That interaction in person is so valuable. So please don't lose that.

Interview with Jake 4-5-22 10 am

Interviewer: I Jake: J

I: What is your employment status and rank with the University? Part time/Full time and Tenure track, lecturer, part time, etc.

J: I'm an associate teaching professor.

I: Within what department?

J: Mechanical engineering

I: How many years have you been teaching?

J: 17

I: How many years have you participated in the academy?

J: Three in total

I: What courses do you typically teach? What courses are you focused on in the Transforming STEM Academy?

J: Sophomore design, there's not a typical one. Sophomore and Junior level courses. For STEM Academy I focused on sophomore design, but I've implemented other pedagogy teaching pedagogy to others throughout

I: What are the benefits you have seen from the academy?

J: Networking for one thing. That's an overall arching. It's so ingrained to me now what they've taught it's hard to decipher how I was beforehand. Some of the tools I use it's more mental tools pedagogy stuff I would say. The classroom stuff peer-to-peer you learn but it's more conceptual stuff I find. Those benefits of being around others that are trying to teach that are different disciplines than you are and think differently to me anyway that's a major benefit.

I: Do you feel that the academy provided you with the tools necessary to transition face-to-face classes to online?

J: Not in particular. Actually yes but I didn't utilize them yet. They could have but not for me particularly.

I: Can you tell me about an example of an evidence-based practice that you have implemented because of the academy?

J: Surveys at the end of class are one that I used. Is it clear and muddy on a note card which is one where you give it out at the end of class. You give it out at the end of class and see what the clearest point was on one side of the note card and with the muddiest point was on the other side of the note card. That's very helpful for the next time I teach it or I can clarify. I can do a couple things I can clarify it for next time some of the muddiest points and also for next year the overall organization of the class gets better or more concise.

I: What was the role of the academy in adopting this practice?

J: I wouldn't have known about it if the academy didn't tell me. I forgot a lot of the technical aspects of it but now that you're bringing it up some of the technical aspects I just implemented and changed the name or what not and I Infuse them anyway. It's infused instead of my classrooms anyway. There's one I remember I actually brought it to them and they started implementing it which was the Course Improvement Committee. Where it is a group of students that help you improve the course and we meet 5 minutes every week or something like that. See what's going on that's super helpful too. That didn't come from the STEM Academy but it's something I shared with the group there and some other participants have started using it.

I: How do you like the change? Do you enjoy it?

J: I don't know if it's enjoy, but it's a matter of driven to becoming a better teacher. I don't know if I enjoyed it so much. I enjoyed the classroom getting better and the students growing if that's the case, and clarifying some things would bring me joy not so much the survey itself.

I: What challenges did you face in implementing this change?

J: The time commitment, not so much the time commitment of me creating it but the time at the end of class takes time away from content. And I know that there is supposed to be time for it, but you're always squished for time.

I: Have you implemented this change in upper-level classes?

J: In all my classes but not every subject.

I: Can you tell me about a second example of an evidence-based practice you have implemented because of the academy?

J: the course improvement committee

I: What was the role of the academy in adopting this practice?

J: That was more of a share. So I brought it to people in the academy. . I thought it was a very useful pedagogy technique to bring to them. They're very open to having different ideas, that was probably the role of the academy as well.

I: How do you like the change? Do you enjoy it?

J: Oh that I did actually. Getting to know students with these large classrooms. I have two classes this semester that are 140 students. I don't know other names I wish I did, but I know the committee's names. I know everybody on the community I know their names their ideas so that's been enjoyable. Things like "I never thought of that", or "oh yeah we used to do that we don't anymore maybe I should." So there's a level of discussion that's enjoyable with the students.

I: What challenges did you face in implementing this change?

J: Actually none. The students are very happy to do it and I was very happy to do it. And then once I did it the students understood. There were times when I couldn't implement the change now so that was a challenge. But I could implement it for next semester so like I said it's a continuing process.

I: Have you implemented this change in your non-STEM Academy classes?

J: Oh yeah I have had them in every class except for the semester I'm trying them out without it just to see what happens. Yes an informal experiment.

I: Did anything deter you from completing or implementing desired practices?

J: No, sometimes I think... Yeah actually some students, it's teaching the students how to learn and what to learn is still a problem. I'll give you an example: some of them just want to be lectured to. I like group work I like them to interact with each other. Like for instance today right before here, we had a worksheet to do I showed them a little lecture and we had a worksheet where we start and stop and I would give them a little lecture and then they would continue on with more questions. I like that it, breaks up the class, it allows the students to interact with one another. There's all these benefits but the downside is people who dislike to listen to the instructor. I have quite a few of them in engineering saying oh I just want a lecture. Well that's not the best way but... That's kind of a challenge changing the students mind. Plus I struggle with if I don't lecture like that I don't get to all the content. So there's this balance you need to do.

I: Has the Transforming STEM Teaching and Learning Academy influenced or led you to change your teaching philosophy? How so?

J: No I don't think it would change my teaching philosophy. It aligned with the teaching philosophy right from the get-go. So there were no modifications to it. I've always been interested in doing group work. So philosophically it was always aligned. The philosophy of transforming stem was always a line since I was beginning teacher. I hated to be lectured as a kid and I still do. I like the work and I think they promote the active learning things like that. And I like the networking. I've always been a fan of cross-disciplinary cultural differences, ethnic differences, you know all these other differences that philosophically makes sense.

I: Has the Transforming STEM Teaching and Learning Academy enabled you to coordinate with other faculty within your department as well as outside your department?

J: Yes. A mechanical engineering as a department, we don't really talk to each other very much. We worked on a group project with another faculty member. That was fun. Seeing how he taught, seeing how I taught, the differences we both brought to the table. We never ended up finishing I think Covid hit and everything was all over the place. We were unplanned to develop a class that I haven't taught since Covid. I've spoken with people from the academy in other areas, but nothing formal though. But the informality of, "hey I know this person in department of math that can help you out." I wouldn't know them otherwise, which is highly important.

I: Were your efforts to transform your course(s) supported and recognized by your department, college, and university? If so, can you explain how? If not, can you explain what would have made you feel supported and recognized?

J: I don't know about the university, but the college - yes and also my department - yes. In our department or encouraged to experiment with different ideas and stuff like that. That's clear from the college level down to the department level. Experimenting in different ways and stuff like that.

I: How would you feel supported and recognized by the university?

J: I don't know that's an excellent question. I don't know. I would have to plead the fifth because I don't know on that one. Possibly just doing this, maybe. Taking some data and trying to create a report to show what it's done? So I may redact my first statement by recognizing that it's still ongoing which is good. I mean from a group level I get it but not from an individual level. Because we did have some administration come and speak with us, which was good, and tell us they support us. One thing I'd like is opportunities possibly to move forward the people that have done the academy, move forward on possible projects. Kind of an alumni thing would be a good thing. See how everybody's doing and see what everybody's doing and see if we can't collaborate.

I: Is there anything else you would like to share with us about the Transforming STEM Teaching and Learning Academy? Do you have any additional opinions regarding the benefits or barriers to implementing some of the evidence-based practices?

J: Overall it's a great experience. And meeting everyone, Tonya and Kathy were great, they tried different experimental stuff, which I appreciate. Some work some didn't but that's how experiments work. The exploration I think was great, the mindset was great. The discussions were great and allowed for differences of opinion and stuff like that. The only thing that I would add is that I'd like to have some sort of an alumni day, to keep it going. There's some people I forgot about, especially now that we're back in person for the most part. That would be useful.

Interview with Jane 4/6/22 12pm

Interviewer: I Jane: J

I: What is your employment status and rank with the University? Part time/Full time and Tenure track, lecturer, part time, etc.

J: Full-time lecturer.

I: Within what department?

J: Math

I: How many years have you been teaching?

J: The first time I thought was fall 2006. So that's now 16 years.

I: How many years have you participated in the academy?

J: I think this will be the fourth year. Third iteration with the first one was 2 years.

I: What courses do you typically teach? What courses are you focused on in the Transforming STEM Academy?

J: I typically teach geometry which is math 3181, discrete math which is math 1165, that normally is either two or three classes because that class typically has two sections but this year has dropped to one section. The remaining one or two classes vary, most recently had it has been linear algebra which is math 2164, and I have some leverage with the Department because that's the one the most recent iteration of the STEM Academy is attached to, but prior to the current Academic Year with STEM Academy that last course varied with linear algebra, differential equations which is math 2171, it typically very between those two every other semester.
Focus on STEM Academy - the most recent year was the linear algebra prior 3 years were the geometry class.

I: What are the benefits you have seen from the academy?

J: I could categorize those in two different ways, in terms of for me personally it has been having a space where I can talk with other people and not just talk to random people in our department that don't like Active Learning and are very negative towards it. And getting that skewed perspective all the time. And actually branching out and talking to people that about it in my department but also across the University. You know it's not just this lone person trying to do these things that are fun and exciting, but actually have some support. So that has been amazing. And specially the first time I did it we didn't have enough money so the little bit of extra money was super helpful not just to get the supplies we need but also to pay that one extra bill. But I can also see it as a help on the actual student side too. Because allowing this space for me to be able to explore all these different ideas, you can really start to see a change with the students as well. Most specifically in my head I'm thinking about the geometry course, because that's the one we started 4 years ago. There were minimal changes the first time of just sort of figuring out what are the things that we can actually do a statistical analysis on and track the benefits other than just seeing their little faces in their eyes light up. Which is helpful, but hard to quantify. I think that was 2018 I think. Which was converted into full on putting the active learning into the course was (and you're going to love this) that same year that we went online. So I have bad data while we were online, but in terms of the data I did collect was getting that they had similar results to pre-pandemic results. So at least we didn't have negative effects while they were online. But this year while I'm not working on the geometry course while I'm working on the other course, I am seeing the actual results now in the geometry class. That course is one of the courses that most math majors and all math minors can take as an elective 3000 level class. But it is required for Math Ed. majors, so the guys who are going into teaching. There is a second course that is for the Math Ed majors, and I've been working with that instructor this year because I can't cover as many topics because we're doing Active Learning. So we're correlating with her to make sure that future teachers are actually getting the topics that they needed for then progressing on to her course. We actually arranged so that if I didn't teach one course she did pick it up. But what she contacted me about this semester was she noticed the students who came through geometry last semester that were now in her class this semester (and I'm pretty sure there's only two of them but) she said that those guys were so excited about the math and so excited about the geometry, that it is actually changing the tone of her class. Of the students not sort of groaning of " hey yeah it's the geometry section of this class" but actually they are really excited over there. And I was like "wow, I don't know what I did last semester, I didn't think it was anything special, but we got to keep doing it." So there's definitely been some effect there and I've definitely been seen it this semester, not so much when we are online but when we're in person there's a definite change in the tone of the classes.

I: Do you feel that the academy provided you with the tools necessary to transition face-to-face classes to online?

J: I don't know if they supplied the tools and the sense of what I did to transition to online because I can't think of any specifics in that part, but I think in terms of having the mindset of knowing to go out and find the tools that I needed was a thing. Because that summer during the spring that we transitioned, it was mainly transition the Canvas course to make sure everyone had everything in a way that they knew exactly where to find things. And then winging it, I mean not really wing it but attempting to give them still all the stuff that they needed, and getting my setup to mimic a classroom setting for them. But in terms of the actual full conversion to online and what I would say a slightly more sane way, not that I was insane before just so crazy on my part, was I worked with a lot of online seminars and webinars and many conferences over the summer. And knowing to reach out and get those, not that I wouldn't know I needed an information, but sort of getting that focus of where to go to get some of those things and knowing that when I had this ad come from my mailbox that "hey this is a great Summer Conference webinar or whatever" to know that this is a great thing and the information will be there. Hopefully we'll be there some of them were less helpful than others. I think there can be a case made that that's where the STEM Academy was helpful.

I: Can you tell me about an example of an evidence-based practice that you have implemented because of the academy?

J: I did several different types of things, and the biggest type of thing that I implemented was converting examples that we would normally go over together in class and instead throwing them out to the students to work in groups. So when people say the evidence-based I always have this brain freeze of - I'm doing things that I know work from people that I've talked to and then where I've seen for these specific classes. So I'm like which one of these are evidence-based and which ones are trial and error, maybe it's really the same thing. But in terms of things that I know have research behind them, that was really, really difficult to find some of these things for a math bent, which is why I had that brain freeze, this group work. Where the students are put into mostly fixed teams, fixed unless there's an issue with a group for the rest of the semester. I've had all sorts of people tell me the different sizes but recently I went to a conference and they were talking about from a research standpoint, three to five students in a team for being The Sweet Spot. I was like, yep that's what I've seen too even though I've had a lot of people say six but now that it's too big for what we do. That one thing right there is probably been the number one thing in terms of really sort of kick starting changes in the class.

I: What was the role of the academy in adopting this practice?

J: Well I thought of teams before, like in terms of how I had done it pre-STEM Academy, it had been things like grab your neighbor next to you type thing for teams always very ad hoc. And those I have found at least from how I've done work inside the classroom is Hit or Miss results. It's really hard to get actual quantifiable data off of those types of teams at least from how I did them in the past. In terms of how the STEM Academy helped, I think some of that was just a push toward reading different literature stuff, talking with other people and conversations. For example talking to one of the people who was one of the visitors who came, they were talking about how they did groups and teams in their class and we got into conversations like around the table, and somebody asked something along the lines of "how do you determine or how do you decide your groups, as opposed to just students grabbing a neighbor. What are the key things you look for when putting your people into your groups?" Because I mean randomized teams you could have a really terrible team, and I really don't want to redo teams in the middle of semester it's a pain in the butt. So getting a couple of that stuff getting stuff like metric stuff- these are things to look for, definitely found in past semesters don't do six for the things that you're looking for that is too many. And then picking those ideas and sort of trial and error, what works what doesn't work what seems to work consistently what works in one course but doesn't work in another course, that's sort of thing. I say really the biggest thing in terms of pulling information from the STEM Academy, really is hearing that one idea or having a conversation with someone about how they implemented something. And especially in math, when you go out and read about these different techniques, you'll have ones that are Humanities based or business class based. As a conference just the other day where most the examples were business class based and I thought "while some of these are really fun but I have no idea how to convert them to math". Or, and this is actually true of some of the things we see in STEM Academy, they are very science-based and sometimes very difficult. How would something that works in chemistry or physics or biology Translate over not to math, just because of some of the scenarios. Some things you can easily see and some things you can't. I have found personally that some of those conversations with somebody, or sometimes more helpful than reading up and papers documents or whatever. Sometimes even webinars.

I: How do you like the change? Do you enjoy it?

J: Oh yeah. Making the team does not fun but once they're made, implementing it the classroom can be very exciting, as long as we're not all asleep, then we have dead time.

I: What challenges did you face in implementing this change?

J: In terms of how I create group work at least so far, most of it is looking at things and converting examples we would have already done in class. So is trying to push it from having you know those two to five students who are always comfortable to answer, getting it out to everybody have a chance to. If not everybody's getting heard by everyone in class at least a chance to talk about and get hands-on experience. So the actual examples that I pick for the team activities are rarely earth-shatteringly new, they would be something that is either already prepped, because none of these classes are new preps, or something that maybe used to be on a homework or something that's at that Bridgeway point. That maybe we haven't covered in class before but I saw that students always missed X, Y, and Z homework questions, and it looked like maybe they needed a stepping stone. So making the actual activities was maybe a little bit time-consuming but not that big of a deal. So the biggest struggle but it's not actually really a struggle the biggest thing of actually getting to the teams is time. If I have everybody registered before that first day of class I like to have the teams ready before that first day of class. Which was not very easy this past semester because I had several classes with their rosters change drastically in those first couple weeks. That is a pain for teams. I've not yet come up with a good solution for that, one of these days maybe. But that right there is actually the biggest struggle I have with teams is actually creating and forming the teams in some sort of meaningful way.

I: Have you implemented this change in upper-level classes?

J: Yes, the geometry class is a junior senior level class and we typically have seniors in that class. I actually implement this across all of my classes. The class that is not tied to the STEM Academy that I always teach is the discrete math class, that class is typically where experiment with things before implementing it in other classes. Because they are Computer Engineering majors so they are a lot more flexible with new things than other student makeups. I definitely experimented with teams and all sort of weird and not good iterations over there and they were still fine. Teams are not implemented across all of my classes.

I: Can you tell me about a second example of an evidence-based practice you have implemented because of the academy?

J: The second thing, I don't consider it a super major thing, but talking to you everybody I've ever told is about they consider this to be a super major thing. Would I have implemented is something, I call them wrap ups, like reflection exercises. So students don't get graded on what they say it's just whether they do it or not. But I have them, and this isn't 100% across all the classes, but the goal once I get this implemented 100% And all my classes is that I would have one of these Reflections / wrap ups after each test, one of the end of the semester, and one at the end of each topic section. In the current class I'm doing with the STEM Academy- linear algebra, I can't remember if I had the test Reflections in that course or not, but that one's going to have one at the end of each topic, and I haven't made it yet but we will have one at the end of the semester. The geometry class I believe only has one at the end of each test and at the end of the semester. And the other class that's not attached to the STEM Academy has a hodgepodge of both. Part of the issue of not completing them right now is I've been using surveys and canvas, which are about to be deprecated, so I got to figure out a way to convert that. But yeah it's good data, sadly I normally pull the data at the end of the semester. But I focus the questions, the new ones for linear algebra, in three parts. The first part is how comfortable do you feel the material, so go to the highlights of each chapter. Scale of totally know what I'm doing to totally don't know what I'm doing, how comfortable do you feel with this topic, how comfortable would you feel if you had a question like this sample. And then it actually gives them to really, really low bar relatively simple examples, multiple choice, and says " hey if you had something like this where would you start?" or " what would you need to do here?" or sometimes just a real question and asks for the answer. And then the third part that I put in this semester, deals with just how the class is going. So," how's your team working out for you?", ", how do you like the activities in class, do you think they are actually helping you learn the material?" And then there's a reflection of like what do you think is the hardest thing you did in this chapter, do you think there's anything he struggled with, how might you approach it differently in the future? The test follow-ups are like that – what do you think you should do differently on future tests, something like that. And unfortunately this semester I haven't had a chance to look over all of those but the linear algebra ones are done on Google forms so I get pie charts. Except for the free response ones, then I have to read all the responses, which is why it hasn't been done yet. I just need like an extra 12 hours a week and then we'll be golden.

I: What was the role of the academy in adopting this practice?

J: I heard that Reflections prior to STEM Academy, but the only type of reflections I've ever heard about were something that I could only picture in a Humanities type course. There was nothing or all that ever had any sort of example that tied it into math. And the examples were always construed in such a way, or at least they felt like they were concerned in such a way, that couldn't even see the transition. It didn't even seem applicable whatsoever. Like the first time I share with my husband that I used a discussion board in a math class, and he was like "that sounds pointless and worthless". And I was like "no, the way it has been used works. Like maybe one or two a semester because I haven't built anymore. But they're actually highly effective if you do it a very, very specific way." But it's the same idea as wrap ups. I was talking with someone who was over in chemistry and she was talking about how she did one of these wrap ups for a test. And I was like "oh that's something I could do "because part of it's very generic like how do you think you did, what do you think you could do to improve. I was like literally any tests those two questions could be asked. Especially with everyone saying taking this moment to have students stop and think about or what they're doing and why they're doing it, gets you away from just memorizing the formula and plugging in numbers into actually remembering it. And this is an issue in math because we have an issue with some of our lower level classes and it can cause an issue in some of our upper level classes of is done too much in our lower level classes. Where they are essentially told here is the formula and I consider it example vomit, they are given every example under the sun, every number just tons and tons of numbers. If they do all the homework problems with every possible number and they don't have to think about the algorithm. Which causes problems in the future. So with these Reflections it was my hope to get them over that stepping stone. Over that transition from just memorizing by wrote to actually think about what in the world are we doing here. So hopefully it works, we've definitely been seeing a little bit better grades, not so much High grades lowest grades but the middle guys, we're not seeing quite as many of them. We're seeing people forget like individual techniques, but having ideas of where to go and guess is where to go and the description of being able to write out what procedure will we do here. They're doing much better.

I: How do you like the change? Do you enjoy it?

J: In terms of my end I just have to type up the questions and make sure they're not stupid and actually relate to what I'm hoping to get them to think about. I make them all great if I completion they're Auto graded now it's super easy for me. So in terms of enjoyment or not, it's one of these things that as long as I remember to do it before the semester starts, super low key on my part. Relatively low-key on their part as long as they actually think about the questions and don't just randomly pick answers. The statistical analysis though in terms of tweaking the course between semesters, that's the part that is actually useful. But in terms of enjoyment, I don't know how to answer that question.

I: What challenges did you face in implementing this change?

J: Remembering to write them. That's literally about it. The only other challenge I can see going forward, is that I'm going to have to transition all of them that I made in canvas to Google forms. And the problem with licking an assignment to Google forms as I don't have that automatic grade propagated into canvas. That is a pain for sure because I leave these open, they are due on a certain date but if they forget they can go back and do them. So remember to pull all those grades, from an implementation it's going to be a pain in the future, but I don't see any downside in terms of the learning standpoint.

I: Did anything deter you from completing or implementing desired practices?

J: So far the only thing that has stopped me from implementing goals that we have had in any of those classes is either time, we just don't have enough physical time to get it done in the semester that we were shooting for. For example last semester I got four preparations, so I had to do some prep for the semester and it just didn't happen, because I wasn't sleeping. And another part for the implementation was last year the conversion to online just took up so much time, doing extra stuff past that, not all of the goals got put in place.

I: How can the Academy help remove these barriers?

J: I have no idea, because a lot of that is just timing. I know that in the future I requested not teaching the summer so I have some extra time. But I mean having something like money attached to the STEM Academy allows me to be able to take off during the summer. That's about the only thing that I can think of right now, just because the barriers I had.

I: Has the Transforming STEM Teaching and Learning Academy influenced or led you to change your teaching philosophy? How so?

J: Not really, probably more doing the things I was always thinking to do, just really implementing them more fully. But thinking back to like the first year I taught in grad school, I did group projects then too. But it was for one assignment type thing, as opposed to fully implementing it all the way across. So I suspect I was predisposed to do some of this stuff anyway, I was just figuring out how to implement it, and getting the sort of support to go for it across the entire course and across the entire semester. And not being completely overwhelmed while doing so.

I: Has the Transforming STEM Teaching and Learning Academy enabled you to coordinate with other faculty within your department as well as outside your department?

J: Yes. Well to some extent shared space. Coming together you natural talk to some people. Think something that was nice is when we would get together in person they would have us sit in tables by Department, not always but frequently, and sometimes that was nice because you talk with the other people in your department which is nice because at the same topic. But sometimes I think it would be nice if they told us don't naturally sit where you naturally sit, go sit at a table with people from not your department. I could see having something like scattered groups that were randomized to some extent being useful there. But yeah some of the guys I talked to outside the department I probably wouldn't have without STEM Academy, because I mean how would I have gotten to know them otherwise other than knocking on doors and that probably would not have happened. Some of the people even from my department I probably knew about 75% of them, but I hadn't talked to some of them before specifically about this. So knowing that they were also interested or at least not opposed to some of these changes was nice.

I: Were your efforts to transform your course(s) supported and recognized by your department, college, and university? If so, can you explain how?

J: Yes? Supported in the sense that the department was like " yes we like you going here". Recognized? I don't think they were recognized at all in the department level. I do know that for the last 2 years, I think it was, I participated in the faculty showcase. So that was I guess would be recognition in terms of University at large or college at Large. I'm not sure. But in general, no not really.

I: If not, can you explain what would have made you feel supported and recognized?

J: I'm not sure. I know that is like the opposite of what the other question was, but there wasn't really anything going on previously. I'm not really sure though. Maybe just a conversation in our department of how's it going what are you doing? That probably would have been sufficient in terms of knowing what was up. I don't know I would have to think about that one.
I: Is there anything else you would like to share with us about the Transforming STEM Teaching and Learning Academy? Do you have any additional opinions regarding the benefits or barriers to implementing some of the evidence-based practices?

J: I can't think of anything off the top of my head. I think you grabbed everything that I probably would have spoken about naturally, plus more. One of the issues I had coming into some Academy the first time is there was the assumption that you knew how to find these evidence-based practices in your discipline. I am not from that Ed I am from pure math. So I know how to go find like research topics in math, but I had no clue how to find any of these evidence-based practices specifically to math. I'm so beautiful assignments like- go find some article about some evidence-based teaching practice in your discipline- that would be awesome but if I know how to find that I wouldn't be in this Academy. So having that one extra stepping stone for people probably would have been extraordinarily nice. Because if I'd known how to find those things, I might not have been part of STEM Academy I might have been like “hey I'm already doing this stuff, and this is one extra thing I just don't have time for like implementing these things." So I can see that being an issue. I know that other issues in terms of implementing things are in a more technical side or logistic side. For example, I got coerced into teaching this summer because everybody else who's qualified isn't around, the room that's not going to work. I can't do teams in that room, it's a hole in the wall, I can't even do things like board work in that room. So luckily they've been very nice and said we'll get you a room that works. But if it wasn't summer, if it was at a really like popular time in fall or spring, this is one of those things where trying to get into a physical location that's going to actually work for the things that you want to do and implement, sometimes that can be really difficult. I'm thinking about this even when we were online with things like Zoom, actually getting some of those physical tools that will Implement these things while we're online, we had to fight to get it approved because we needed a paid subscription to this tool so that we could do math in teamwork when students virtually coming to class. So those type of things, I don't know what some Academy can do to fix that, unless throw more weight around to get more active learning classrooms. That would be awesome. But yeah there's definitely still some barriers to fully making sure all of this stuff works. I know that we used to have notices about getting access to Active Learning classrooms, but I haven't seen any of those in recent years. I don't know I don't have a solution to for this because it's not like the university is going to change over all their classrooms.

Interview with Netty: 4/8/22

I: interviewer   N: Netty

I: What is your employment status and rank with the university?

N: I am a lecturer, full time

I: Within what department?

N: Physics department.

I: How many years have you been teaching?

N: Several years at UNC Charlotte, or in general?

I: In general.

N: More than 20 years.

I: How many years have you participated in the STEM Academy?

N: I think, I can’t really tell you for sure. I participated a lot of the time on workshops that looked interesting. So it has been at least 5 years. But it is just on and off. If I see any workshop that they announce, and it looks interesting, I participate. And sometimes our department chair encourages us to participate, so then I sign up.

I: And with the Transforming STEM Teaching and Learning Academy with Dr. Asala and Dr. Bates, you have been participating just this past year?

N: Yes.

I: What courses do you typically teach?

N: Most of the time I teach the algebra based mechanics, that’s the first semester. And algebra based second semester which is electricity, magnetism, and optics.

I: And what courses are you focused on in the Transforming STEM academy?

N: That would be the second semester, which is the one I’ve been teaching the last 4 semesters.

I: What are some of the benefits you have seen from the academy?

N: I think, because I have been participating in these workshops on and off. I noticed that my teaching style was in some ways the way they encourage us to do. From this one year that I have been with the cohort. I find that, it is basically confirming a lot of the things that I already do anyway. But then I got one thing that I was having a hard time reaching students. They would not come to class, and they would also not watch the videos that I had already posted. So then I got some ideas about how to engage students. Because I do like, and I do not use Poll Everywhere, because in my mind, it is just a gimmick. I don’t think it really tests anything. So, but now I’m giving some Canvas quizzes that are based on the lecture videos.

I: Do you feel that the academy provided you with the tools necessary to transition face-to-face classes to online?

N: That was before. We had to do a quick transition. At that time I was involved with physics in the first semester, and that time we, I had gotten, I had taught summer classes, and so I had experience with online teaching from summer sessions. But at that time, we had to very quick transition in the middle of spring semester of 2020. We were able to do it. We did not really require any help from CTL or anybody else. But the summer session, they did give us help. But again, because I had been teaching it for a long time, I already know a lot of things that was available. So if I needed help, I got help. If that answers your question, but I did not really need as much.

I: Can you tell me about an example of an evidence-based practice that you have implemented because of the academy?

N: It is the one that I just mentioned to you. It is about engaging students to ensure that they are watching the lecture videos. So I give them, I have my PowerPoint slides; it has some things written, but a good amount it blank. So, I ask them questions, which actually is very simple. All I want them to do is notice what's in the slide. That is an idea I got from talking to in the cohort. We discussed it last year. I implemented it and seems like the students like it. And the fact that it is not timed, they are not pressured. They have the whole thing in front of them, all they have to do is spend the time and answer it. But there is a deadline. I give them one week. I usually open it on Monday and close it on Friday night. And then I give them two days of grace period with 50% penalty. So earning point is very easy, but then if they don't watch it, then they get 50% off.

I: Do you like the change? Have you enjoyed implementing it?

N: Yes. I won't be able to use it in summer session, I think, because my manpower is less. But I do plan continue doing it during regular semesters because I ask students every now and then, and they do like it. They like that fact that, what I did was I took some percent out of exams and used that over here, so this is an easy way for them to earn some points.

I: What were any challenges that you faced in implementing this change?

N: Well I always made my own questions. That is not the problem; the problem is that I need more manpower, because somebody has to create them. So that kind of limits me in what type of question I can ask. I mean, I do ask some questions that is computer graded, but to really make sure it is not just a random guess, I do like to use questions where they have to write something. So, the problem is getting enough manpower to grade it.

I: Have you implemented this change in any upper level classes?

N: I do not teach upper level.

I: Can you tell me about a second example of an evidence-based practice you have implemented because of the academy?

N: Um, not now, because I have been using these methods always anyway. Um, I mean. Trying to make sure that the course objective is aligned with what the students are learning, and being conscientious about it. That is something I have been following for several years, it is not just this year.

I: Did anything deter you from completing or implementing desired practices?

N: No. I got all the support I needed.

I: Has the Transforming STEM Teaching and Learning Academy influenced or led you to change your teaching philosophy? How so?

N: No, it was already aligned with this.

I: Has the Transforming STEM Teaching and Learning Academy enabled you to coordinate with other faculty within your department as well as outside your department?

N: I got into this during the pandemic. We were socially distanced. We don't see very many faculty these days. I got into after two other faculty from our department also participated in it the first year, I think. So, I spoke with them, but we did not, we were not co-teaching anything. But, I did speak about it with our lab coordinator, and try to see if we could somehow get him involved into aligning the lab course with the regular course. That is a work in progress.

I: What are the benefits from coordinating?

N: Well this time, the course that I'm teaching, it is just with myself. I am not coordinating with anybody else. So, I can't answer. It is not applicable.

I: Were your efforts to transform your course(s) supported and recognized by your department, college, and university? If so, can you explain how? If not, can you explain what would have made you feel supported and recognized?

N: The department definitely. I can't say anything about college level. I don't see anybody complaining about it.

I: How did the department recognize your efforts?

N: I am getting… I am mostly a hands-on person myself. But if I request any help, I am getting it in the sense that like if I request TAs and stuff like that.

I: What would have made you feel supported or recognized by the university?

N: I really don't know. The university is big. I don't know. I can't answer that, sorry.

I: Is there anything else you would like to share with us about the Transforming STEM Teaching and Learning Academy? Do you have any additional opinions regarding the benefits or barriers to implementing some of the evidence-based practices?

N: I think it is great, what they do. Because I thought, in my mind everything is just logical and straight forward, but then sometimes, when I listen to some other faculty, I hear from them a lot of complaints like; the students are studying, they seem to want to get freebies, and so on and so forth. And maybe it is true about some students, but I think the majority of the students are not that way. So I think when you try to align, you know you have to design your course based on where the students are, and then bring them up. Rather than stating that I'm teaching here and the students are at the low level. Just saying that well, I'm not going to… just kind of writing them off. I don't think that is the right thing to do. I mean, there are some students I can't reach. They don't come to class, they don't do anything, and when they do come to class I can tell they did not study anything, did not ready anything, they expecting to learn everything just in that one hour of class, and that never happens. But then there are many students who are coming from weak backgrounds, but that is not because they don't want to learn, it is just that they didn't get the level of education they should have gotten when they came. Then I say well, that's fine, but here we are, so let's do the best we can. And I try to give some background, but I do tell them that this is not a math class. If you need some math background, you need to go and get it from math. Because I cannot spend my class time teaching somebody math who doesn't know math. I can teach Physics, but not math.

I: Do you have any additional comments about barriers to implementation?

N: No, I just do what seems logical to me.

Interview with Mary 4/12/22 10 am

Interviewer: I Mary: M

I: What is your employment status and rank with the University? Part time/Full time and Tenure track, lecturer, part time, etc.

M: I'm an assistant professor in Department of biological sciences

I: How many years have you been teaching?

M: I've been at UNC Charlotte since 2018, so it is my 6th semester of teaching.

I: How many years have you participated in the academy?

M: I started in August of 2021, so less than a year

I: What courses do you typically teach? What courses are you focused on in the Transforming STEM Academy?

M: I am teaching the hypothesis testing course which is a graduate course in biological statistics, and I have been teaching Marine ecology of 4,000 level course, and introduction to Marine Science which is a 3,000 level course. For STEM Academy I'm focused on ecology, which is one of our core courses.

I: What are the benefits you have seen from the academy?

M: The primary things that I have seen is that I know where to get information to create different types of activities in my classroom. So even if I haven't implemented them in the ecology course, because I haven't taught it recently, I have implemented them in the other courses. So knowing where that information is, learning what's out there from my peers, has been so very valuable. And learning about the resources on campus. So those are the big three, so just being aware of the material, knowing where to find it, and the people on campus that can help you with it.

I: Do you feel that the academy provided you with the tools necessary to transition face-to-face classes to online?

M: I did the transition before I started in the STEM Academy. I think that there are some aspects of the STEM Academy that helps me be more engaging and structure whether it's online or in person.

I: Can you tell me about an example of an evidence-based practice that you have implemented because of the academy?

M: I have started implementing alternative assessments for my course. And also seeking input from students about what are the things they want to be tested on based on the learning outcomes that I have outlined for them in class. I think that has been beneficial in kind of helping them to get ownership of the material. I present them the learning outcomes and then I have been polling them on the ones that they consider to be the most important, and they basically are creating the content for the alternative assessments. I think that's worked very well.

I: What was the role of the academy in adopting this practice?

M: I think that there had been some things that I was aware of, but didn't actually have the time or the opportunity and the feedback to develop those ideas. So the STEM Academy just gave me, gave me that time and gave me that feedback and the tools to organize myself. So there was always some things that I thought, “oh wouldn't that be fun" but I didn't actually have the tools to do it before the STEM Academy.

I: How do you like the change? Do you enjoy it?

M: Yes. I think that I was probably resistant to implementing assessments that were not traditional. And now I don't think I'm going to go back to traditional assessments.

I: What do you see as traditional assessments?

M: Make more standardized multiple choice assessments. I use those types of questions but more for practice before the content is presented, but not for the assessment itself.

I: What challenges did you face in implementing this change?

M: I think just having the time to organize and to make sure that I work out all the kinks. Because it's the first time that I'm teaching this course, and also trying to implement these new activities. So it's a balance between bringing in the content and also trying to do it in an active way. That has been the biggest challenge is just the time.

I: Have you implemented this change in upper-level classes?

M: I have done a couple of things in my hypothesis testing course. So last fall we had started talking about open source resources and we started talking about things that would engage students online and that sort of thing. I included some of those activities in those materials in my class.

I: Can you tell me about a second example of an evidence-based practice you have implemented because of the academy?

M: I kind of gave you three and one maybe. But the learning outcomes, I think that that was the one... Like I've done alternative assessments, but communicating the learning outcomes - I didn't realize how that would impact a students. And they were like oh that really is helpful. You assume that they're going to fill in the blanks. So I think besides the alternative assessments that I told you about before, I've been making sure to tell students what they'll be able to do after the end of this section or module.

I: What was the role of the academy in adopting this practice?

M: Just having a better understanding of how to construct them. And which ones would be most appropriate for different levels of students in terms of their career.

I: How do you like the change? Do you enjoy it?

M: Yeah I think that it empowers students when I tell them what they'll be able to do.

I: What challenges did you face in implementing this change?

M: So this is a good one because there are some things that you're just, "if I can't come up with what they'll be able to do, then is it worth me teaching it?" So I've been cutting material just because I find it interesting to talk about, because I've been balancing the needs of the student versus my need to share stuff that I considered to be fun or interesting. That was the biggest challenge, because I realized, “oh no maybe I don't have a reason to talk about this because it doesn't contribute to that learning outcome.” So just cutting content.

I: Have you implemented this change in your non-STEM Academy classes?

M: Yes.

I: Did anything deter you from completing or implementing desired practices?

M: Just time.

I: How can the Academy help remove these barriers?

M: Well I think that it's helpful to have these. I like the schedule on Fridays, the fact that we always have an opportunity to work on our materials. So that has been helpful. That has become the de-facto teaching time to prepare for the next week for me. I'm just thinking about, “okay these are the kinds of things that I need to prepare for.” That has been helpful. I don't think the STEM Academy can do anything about my other responsibilities.

I: Has the Transforming STEM Teaching and Learning Academy influenced or led you to change your teaching philosophy? How so?

M: Yes. In particular thinking about what students will be able to do. And just teaching students to do things as opposed to memorization. I think there's a difference between the content, teaching them content or providing them with content versus teaching them how to find reliable sources and had to evaluate sources. How to be critical thinkers. Had to summarize information. And so the doing, what you will be able to do has helped me to transition towards less of a Content based and more of building skills. And I've had feedback from students that like it when I teach them how to do things. And it's like I'm just tricking you. So it's like teaching them how to find research articles, instead of just telling them to do it we have an activity in the library in class together. And so that builds on the final project, and that was in one of the first classes but it builds on the final project. The students are like this is great. And I said what do you mean it's great? I thought it was just review, and it was not review for them. Nobody had just sat there and had them do it. Like I tell them now the world is yours. There are billions of articles out there. It's not about you memorizing content, it's about you knowing where the information is when you need it. That really changed my Approach.

I: Has the Transforming STEM Teaching and Learning Academy enabled you to coordinate with other faculty within your department as well as outside your department?

M: We have three people in the STEM Academy who, we are part of the ecology rotation, So we've been working together on the STEM Academy activities. We have other faculty within the department that also teach that course but we haven't done much communication or coordinating with them yet besides just telling them that this is happening. I think that that's the challenge in bringing those, bringing that knowledge to the department to be implemented In a broader scale. I see that as the next challenge.

I: What are the benefits gained from coordinating with other sections/instructors?

M: I've learned a lot from my two colleagues. They are amazing they are both amazing instructors. I just sit there in awe and try to absorb the things that they know. So it's been great to use them as a sounding board when I'm developing an activity. Besides Tonya, they're definitely my go-to people. So it's been good to have that relationship with them.

I: Were your efforts to transform your course(s) supported and recognized by your department, college, and university? If so, can you explain how? If not, can you explain what would have made you feel supported and recognized?

M: Yes my chair was very supportive about this, and she'll probably be somewhere about us maintaining this effort. But I have not have a conversation with her about joining for next year. That's on my list of things to do this week. I don't really know how much support the dean and the Provost provide for this type of professional development. We'll see it on my merit form if they appreciate it or not.

I: What would have made you feel supported and recognized?

M: If it's something that they value when they're evaluating me.

I: Is there anything else you would like to share with us about the Transforming STEM Teaching and Learning Academy? Do you have any additional opinions regarding the benefits or barriers to implementing some of the evidence-based practices?

M: I think I've said it all, but I found it to be very valuable. My challenge to the people who support it and run it and are in the program itself is to think about ways to engage the larger community. And come up with ways to really sell this idea, because it is I think very important. And I can see how students are more engaged, and value the changes that we're making. But we're in a room together we're just preaching to the choir, and I don't know how to expand that. So that's a challenge. So that would be my feedback, please come up with a way to sell this.

Interview with Ben 10-14-22 1:35 pm

I: What is your employment status and rank with the University? Part time/Full time and Tenure track, lecturer, part time, etc.

B: I am teaching professor, not a lecturer. So a teaching professor is my rank. I am not a tenure track, most teaching professors are not tenure track. With the department of computer science.

I: How long have you been teaching?

B: 22 years. This is my 23rd year.

I: How many years have you participated in the academy?

B: Probably about 5 years… Every year except last year. I participated whenever it started except last year. So maybe I'm mistaking the STEM Academy and the active learning academy. But the active learning academy I was a member of, and didn't participate last year because of Covid stuff. But I don't know what the STEM Academy is.

I: It was with Kathy Asala and Tonya Bates. They were running the STEM Academy.

B: Oh, I think I was there one year. Yeah, one year only. And I think it was during the Covid year, so 2020-2021.

I: What course do you typically teach?

B: I teach programming courses and data structures and software engineering.

I: What did you work on for STEM Academy?

B: Intro programming course.

I: What are the benefits you have seen from the academy? Do you feel that the academy provided you with the tools necessary to transition face-to-face classes to online?

B: Well, honestly, we did something over there with some planning, but what happened was I had to switch to a different course. But the plan was built, and therefore whatever we did, I was not apart of anymore. So, I don't know how to talk about that. But in a general sense, there was useful discussions and helpful activities. The reading was useful, it was about active learning. Some of what I remember, but I basically focused on totally a different type of courses afterwards, and another group took over that whole change of... I don't know if they came to the STEM Academy the following year or not.

I: Can you tell me about an example of an evidence-based practice that you have implemented because of the academy?

B: I honestly I don't know, I don't remember having done anything based on the academy. But I do evidence based, I've been doing that since before STEM Academy. So if I remember if anything from that Academy, I don't remember that. So I can talk about practices I've been using.

I: Yeah, I would be interested to hear about practices you've been using most recently.

B: Well, as I said, the evidence based is pretty generic these days, but what I call evidence, the definition that I like to call evidence is you can sort of see the pattern of [*indistinguishable*] staying around for a longer time. So I do a lot of quantitative analysis, as opposed to traditional qualitative analysis. And I feel it is easier to make evidence than stories, but I see people who use stories a lot and it is very acceptable in the discipline. In particular as far as the evidence of looking into students' reflections. I have a couple PhD students who are doing their dissertation on that right now to use students' reflections to get information that could be used for improvement of the teaching. So I use student reflections as the evidence plus the observations and things like that, but I try to use that one for the most part.

I: Can you describe some the active learning practices that you like to implement in your classes?

B: In terms of active learning, there are two sides to that; the technology side and there's pedagogical approach. So pedagogy I developed a model and published a paper on it, couple papers for different type courses. I also in the active learning academy book, I wrote a chapter on that. That was for introductory courses. And I further developed the model, use the model as a sort of a gateway in a junior level course. One of my students who was coauthor on the paper and the chapter, she is a PhD student but also she is teaching, she is using that to develop a course on that model. So there is a pedagogical approach based on the fact that to be, to have a collaborative, a productive and collaborative learning everybody should be on the same level of readiness. So the prep work needs to be designed in the right way, and needs to be reinforced. And the activities need to be consistent with that, and some sort of post-activities for continuity and learning purposes. So basically, the knowledge gets stuck in the mind. From the tool standpoint there is obviously Poll Everywhere, Kahoot, that kind of stuff, which within the pedagogy that works.

I: What challenges did you face in implementing this change?

B: I think Covid was a big problem, because online active learning is still more of a theoretical claim than an active practice. Now some courses that are discussion based course you can do better on that. But if there is some deep knowledge and then there are some activities that require social interaction of the students, social learning, collaborative learning, then Covid really screwed that part up. Most of my courses were like that, discussions you can simulate it in other ways, but the interactions and the collaborative learning is the problem with a totally, fully online class.

I: Has the Transforming STEM Teaching and Learning Academy influenced or led you to change your teaching philosophy? How so?

B: No, I think I had my teaching philosophy set up before that, I've been practicing active learning for a while, published many papers on that. I've been doing projects on students' success before. It was useful information. The only problem with STEM Academy was it was designed before the Covid time, and then right into the Covid. A lot of the problems were not hitting that. I don't know how they adjusted to that. There was a lot of "let's do this, let's do that", but there was not a lot of evidence of how it works, and some people didn't know how to practice it.

I: Has the Transforming STEM Teaching and Learning Academy enabled you to coordinate with other faculty within your department as well as outside your department

B: No, as I said, because that assignment was switched and I changed my concentration. I don't know if the new group that I joined had its own coordinator and that kind of stuff, we were following that or not, we were just having our task and we had to quickly get into those. I don't know if we particularly focused on anything from there. Whatever was learned was learned and practiced, I can't per say remember of anything from that year like that at this point.

I: Were your efforts to transform your course(s) supported and recognized by your department, college, and university? If so, can you explain how? If not, can you explain what would have made you feel supported and recognized?

B: Yes, so there's been an effort. In particularly the fact that I do it as a CS as research and also connect those two grants and supported projects, I've been given recognition based on that. But I feel that still needs to, needs more work to be done. I mean one mission of the University is to offer good teachings and learning. Therefore there should be more incentives, and more encouragement and more recognition. I don't think it's enough. It's not for me, I'm talking about the junior faculty. People like me, I have my own motivations to do stuff. I don't know if that would be the case for everybody without having a good encouragement model.

I: Is there anything else you would like to share with us about the Transforming STEM Teaching and Learning Academy? Do you have any additional opinions regarding the benefits or barriers to implementing some of the evidence-based practices?

B: I think these things are very useful. The ideas are very useful. The models are very useful. But, again, the sustainability, continuity, all these are issues that need some sort of a flashback, so I'm glad you are doing this, because I sort of forgot about it. It would be useful if they could give something back, some refresher of lessons learned that can be shared further. Assuming that people come to Academy and do x, y, z, is a good assumption, but it needs follow ups and certain types of things. So I don't know how that is done.

I: that's sort of what my project is starting with. Do you have any additional opinions about the benefits or barriers of implementing some of these evidence based practices?

B: It's useful. I think it has to go beyond certain level course. Obviously there are core courses there's larger course, but it basically has to be overall, to everybody. And rather than having the same people taking it again and again, lets bring the level up. Make everybody highly educated and lets have another round of higher, deeper knowledge and interaction. I think that would be more useful, and repetition provides enough interactions of you know, "what did you do, what did you learn, how did you change it", because these aren't very specific courses, and there's no one-size-fits-all solution.

Focus Group 1 – 2/21/24 at 4 pm

Number of Participants: 4

Speaker Designations:
0 – interviewer
1 – participant 1 ("Janet")
2 – participant 2 ("Doug")

3 – participant 3 (“Felicia”)
4 – participant 4 (“Steve”)

0 - Thank you all so much for coming to this focus group. Everyone so far has gone through and read the consent form and signed it, which is great. So you have a bit of an idea of what we're doing today. So what I'm going to be doing is running through some of my questions here. I'll take a few notes just in keeping track of who's talking, when for, when I do the transcription, Um and check through those things, you won't be identified by your name or title or anything like that but you might be identified as “A professor who teaches these types of courses or has been a part of the University for this long of time” or uh, or “teaches these types of students”, just to give a little context to your quotes, but they won't be attributed to you, uh, directly. So you can say whatever you feel like and be as honest as possible.

Question 1:

0 - And so, what I want to start with is just some background information, so if everyone could tell me who you are and which classes you're currently teaching at the University, We can start from any direction.

1 - I'm Janet, um, currently, I'm teaching CHEM 1251 in General chemistry one and CHEM 3121 in organic chemistry.

0 - Okay. And Doug, what about yourself?

2 - I'm Doug. I teach in the Math Department. Teaching Calc 1, Calc 2 and differential equations, right at the moment.

0 - Thank you.

3 - I'm Felicia. I'm in the biological science department and I teach right now, this semester, I'm teaching principal pathology And a special topics biology class in Animal Health. I also teach other classes, parasitology and Um, so that would like to show The lab section of the principles pathology sometimes.

4 - I'm Steve. I'm in the department of chemistry. I'm currently teaching the second semester of a two semester of physical chemistry course. Um, in the summer, I teach General chemistry one. In the fall, I either teach graduate course, nanoscale phenomena or physical chemistry.

Question 2:

0 - Thank you. Um, what motivated you to participate in the STEM Academy originally.

4 - I remember there was a payment.

1 - I was encouraged by colleagues and I didn't know what it was, but it sounded fun.

3 - It sounded like something interesting. I wanted to know a little bit more about teaching when I first came here and started teaching I had more research experience than teaching experience. So I would try to get into any kind of teaching, related discussion groups that I could.

2 - Teaching for a long time, but I realized Um, There's still a lot of stuff, I don't know. And so anything that I can pick up from people that know more than I do. I'm very happy to steal from.

4 - Yeah, Kathy Asala described it and it sounded compelling.

Question 3:

0 - Thank you. Um, so if you were to walk into a classroom that was using evidence-based teaching practices, what kinds of things would you see and hear in that classroom.

4 - Maybe see students working instead of professor's talking.

0 - Take your time.

3 - Probably the students would be more. I guess interacting with each other, trying to figure out that evidence. Um and connecting it. That's at least the idea of connecting with the topics. Hopefully, there's a little more interaction between students, which sometimes is lacking. Um, there's interaction with the instructor and then there is no interaction.

2 - And I can see engaged students talking with themselves talking with the professor. Talking and trying things. Hopefully getting some stuff right and probably getting some stuff wrong, but not getting discouraged by it.

1 - Yeah, I don't have anything else to add. I agree with all of those.

Question 4:

0 - Right. Um, could you describe something you learned from your time in the STEM Academy and how you have used it in your teaching practices? I know some of you are new to it and some of you it's been a bit of time since you worked with it from that first initial…

4 – I really like the exercise where we mapped activities to our learning objectives. I sort of maybe done that mentally but never really physically written it down and it helped me organize a little bit better.

3 - I have missed that part but I've done it in I think I had similar exercise through, uh, one of the CTL workshops that I did, where they were talking about learning objectives and thinking about the topic content that you're trying to teach and how you would connect that with different types of activities.

2 - Sorry, could you repeat the question? I didn't quite hear it.

0 - Yeah, I want you to describe something you learned from the time in STEM Academy and how you've used it as your uh, in your teaching practices.

2 - Okay, thank you.

3 - I also like teaching, um, like using the I think we there's several courses that and that's I'm trying to maybe confuse things there. Uh but I think we also talked about um, some learning versus like, studying different methods of learning. So I tried to use that when I'm talking to students, because for some of the freshman classes like the principles pathology, a lot of the times, I feel like they are not they're, they're trying to just memorize and pass and not necessarily try to think a little bit more so try to get them to think a little more. Differentiate between learning and just studying.

1 - I learned, I really liked when we had to put together an activity, I don't know when this was last semester, maybe based on one topic that we teach, or we had to outline our learning objective, our prerequisite knowledge for that thing, our goals, and then kind of put together an activity. Because I never really did, I thought it was really helpful to think about like what are they coming in knowing for this particular thing and what do we need to remind them that they already know to help guide them to learn it? So I then used that activity that I made for class.

2 - I appreciate getting those some of the kind of um highlighting things that a lot of us, just take for granted. And we do naturally because quote “We're academics”. And so, um, like, one thing was just giving the students… Well these are the things that we've done this whatever module, that they're expected to be able to do on the next exam. And you know I mean to me that was like well yeah, that'd be step one, but to a lot of students it doesn't even make the top fifty things to do list. And so anyway, I've just appreciated um, you know, it's not it's not giving away the store but it's just kind of helping them to start realize, you know, to start prioritizing and how to think about, even how to think about study or how to think about learning. Uh, again a lot of things that we just kind of, I don't know, take for granted or do naturally, or we've done it so long we've forgotten that it was a struggle for us or something like that, but to bring that out into the open.

1 - Oh, I also we learned about, um, using AI like specifically. We had a whole day where we talked about using chat GPT and we like talked about how we could use it to help us in the classroom. I mean it also has a lot of downsides but um, and so I've actually been sometimes I will use it to like I'll ask it a question based on something we're talking about in class. It will give a very wrong answer but it sounds misleadingly correct. And so I've used that as an activity in class to show students like does chat GPT know what it's talking about with this topic and if not what's wrong with it and I think that was that was a good thing. I would have never tried that I think without having that time in stem Academy.

Question 5:

0 - Anything else? I would like to add? Okay. Um, so the next thing I want to know about is what has been one of your biggest frustrations or barriers when implementing some of these new teaching strategies in your classrooms.

2 - One of my teaching strategies seems to be sorry. Seems to be geared to, you know, a classroom of four people or something. None of us have that situation, so that's.. It sounds really good in a really, really small control setting but that's generally not reality.

1 - Yeah, and teaching in like Burson 110 with 180 students, it's very hard to gear activities in a way that can be impactful. Um, I think time management is a big problem for me in some of these activities also because I know how to get through material fast when lecturing, but that doesn't mean it's effective. And so I have a that's one of my biggest hindrances in some of these things is I don't know how to cover all the material and still effectively, get through it all.

4 - One of my challenges even with the smaller like a Pchem class, but, you know, obviously, General chemistry is really hard to get them to do activities. In general Chemistry I'll do a, you know, pair up and share, kind of thing at the most and of course, you know have them report out on their work. But, you know, I try to get them to do a lot of work at home, right? That's what we learned; pre-lecture videos, do these work? Make sure you know this before you come to class, pre-lecture video quizzes. And, I still and I know I'm not supposed, to I still teach the stuff I expected them to learn already. Because they didn't learn it. When it comes time for an assessment, they do poorly. And so, I spend less than each year past. The time I was told to do these great things. I spend less and less time doing those activities in class. Because I still feel like what I deliver in the classroom is more valuable than them sitting there talking about a problem for 5 minutes. I know it's not the right thing to say.

1 – But it's true.

0 – It's the reality.

3 - You're the one making the videos, but when they hear it in person, somehow it makes a difference. And they will, I have had students who will say that, "Now that you explained it, it makes better sense", but I am the one that explained it in the video too. One of the things that I noticed, um, with this book as we were reading different chapters, or at least the part that I was reading, many of the examples are given um, often with Uh example, questions are, how does teachers are based on Some type of quantitative concepts or, you know, that can be, you know, analyzed step by step, you can do it in steps, which is hard to do with the topic that I teach. Um, there is often no clear-cut, you know, steps to giving partial points or things. So, it relies that I don't want to call it memorization, but it does, you know, end up being able to understand the concept or not. And there's not much I can do to use those examples and think about a similar situation with topic that I teach. I always wish that there were Biology examples or maybe some other type of examples.

4 - My experiences taught me, sort of reinforced, what I thought about online courses and that is like what you're (referencing Felicia) saying - They get very little out of it, I'd imagine. It's a very passive way, I mean, the way that students watch these things are on their phone in their pajamas, you know, doing whatever they do. Uh, but when they were the classroom, and I'm standing right next to them and, you know, we're having a discussion about it, you know, more active. So I think that's why I do both but I don't rely on them getting that learning before the class.

3 – I've started converting, some of my online classes to hybrid classes where I see the advantage of having that online component, where you can do a lot of the pre-assignments, quick reading, watch this video be ready and come to class and we'll discuss will clear any confusions that you have after you have watched the video. And sometimes they don't want to say in the beginning, the first couple of weeks of those hybrid classes, they did not want to ask any questions, they acted like they knew everything. They did the first test and it was clear that they didn't know everything that they thought they knew. Then we started, you know, I would start picking on like let's let's do a mini quiz when you come to the classroom and I'll uh, like just with poll everywhere or even something else. Where I know that, if the class here knows an answer to something or not, if not why not. And explain the explaining things like that. And once I would explain something then I would connect something else to that topic and then kind of go over different parts of the lecture that I have provided through the video and make them, you know, do some of the life cycles and stuff in class or in groups where they felt like they're not just listening to me. Just doing a little bit themselves.

0 - Any the other frustrations or barriers specifically that you wanted to mention.

Question 6:

0 - All right. Um, so the next thing that I wanted to know more about was uh, how would you describe the response from your peers and administrators outside the STEM Academy, uh, to the teaching strategies that you're trying to implement in your classrooms? So, for those who haven't been a part of the STEM Academy directly, do you see a different response or positive negative whatever it might be to talking about these different strategies or trying new strategies in the classroom?

4 - I honestly don't think I've had conversations with people who are not part of the academy. Yeah, administrators have not asked me, "What's new?"

(General confirmation from 1, 2, and 3 to this statement)

3 - And the discussions with colleagues, I think varies if they are part of STEM Academy or are interested in Active Learning or in newer techniques that we're trying to learn or discuss. They like it, or they're all for it, but then I have also seen, you know, some faculty member that think this is a total waste of time. "Why are you trying to reinvent stuff?" "You go in the front of the

classroom, speak, you're done. That's it.” I've seen that type of [sic] reaction as well, not necessarily administrators.

2 - So the administrators I've been around are happy as long as they're not being bothered by your students.

3 - As long as there's no complaints.

0 - So, would you say that administrative level, you're not hearing positive or negative, you're not really hearing about STEM Academy or trying to encourage people to join STEM Academy or do something similar. And at a peer level either, they're part of it or they're not interested, would that be a fair assessment?

1 – Probably.

2 – Yeah.

3 - For me, that's what I see.

4 - I think if we started having like a zero DFW ratio or something like that, they would take notice. I don't know. I don't know how they would know otherwise, even the chair. You know, who knows if they know what we're doing. I never see it my year-end evaluation.

Question 6a:

0 - Uh, so what kinds of responses? Contributed making you feel. Supported or recognized for implementing these teaching strategies, or what kind of responses would you want to hear or want to see for implementing these new strategies.

4 - I think I've had positive conversations with faculty who've been through the STEM Academy teaching similar courses. We talk about different strategies, approaches, and that's nice. It's like a community based within the department of Chemistry. But otherwise…

0 - Is there anything you would say, um, with something you would like to see had been doing or getting more involved, or do you think it works the way it is at a colleague level at this point?

4 - I think there could be maybe more resource sharing. It might make it easier for other faculty to do more. I'm not I've never been asked to share resources or nobody's ever asked me to share my resources. Oh actually, I lie. So the physical chemists, we should have resources. But, I don't know at the general chemistry level, I don't know what the activities are like, this is what we're doing,

1 – We tend to share a lot, but yeah.

Question 7:

0 - Anything else? Okay. All right, um, What aspect of the STEM Academy has been most impactful for your professional development?

2 - Honestly, just the personal relationships and seeing a room full of people that actually care about teaching. Um, you know, at least in our department, you're not generally, you're not going to walk into a room where that many people care that much about what's going on in the classroom. Sorry, it's kind of nice to see everybody pulling into the same direction.

1 - I think it's also nice to just have a dedicated time every few weeks to just sit and not think about like the little granular things that I have to do for class and it's a good time to just kind of like sit back and look at it bigger picture which I wouldn't do otherwise. I don't think I would carve out time in my schedule to really like look into new activities or new like new ways of approaching classes. So to me, it helps with my time, I think.

3 - During the discussion that we have each time we meet, some of the examples of activities that other faculty members are doing, you can maybe not utilize the whole thing, but at least take parts of each or like you know some of those activities or ideas that others have and try to think about how you can improve either existing ones in your class or make a new one if possible. That’s good development.

Question 8:

Um, is there anything you'd like to mention that we haven't discussed? Uh, today during our focus group?

Focus Group 2 – 3/1/24 at 1 pm

Number of Participants: 5

Speaker Designations:
0 – interviewer
1 – participant 1 (“Grace”)
2 – participant 2 (“Peter”)
3 – participant 3 (“Bobby”)
4 – participant 4 (“Nancy”)
5 – participant 5 (“Elaine”)

Question 1:

0 – So our first question here is just to get to know everybody. Um, so could you please tell me who you are. So uh how long you were have been in STEM Academy? How long you've been teaching? And what kind of classes do you, teach typically? And anyone can get us started.

1 – I'll go ahead and get it started. My name is Grace I'm in the math department. I typically teach freshman level math and statistics. I've been a part of the STEM Academy since the beginning but sort of off and on. So four years off and on was there another part of that question?

0 - How long have you been teaching?

1 - I've been teaching for about nine years.

2 - Okay, Um, I'm Peter. I'm in the department of geography and Earth Sciences. Um, I teach a combination of geology and environmental science classes. Both at the intro level and sort of the junior level, I guess is what we call my upper division classes. Have been here for 20 years and teaching for 21. I taught a year last year in graduate school. Um, and I think this is my fourth non-consecutive year in STEM Academy, okay?

3 - Yeah. All right, uh, I'm Bobby I'm from the physics department. Um, This is my second year at UNCC, so I guess I've been teaching maybe for three years. Um, I don't even know, I haven't even been here a full year for STEM Academy so and I missed half of last semester I didn't know it was going to be on Friday when I signed up. So, maybe four months in the STEM Academy.

4 - Hello. I'm Nancy I am faculty member in the College of computing informatics. I teach computer science and I teach across the board intro, you know? Upper level and graduate, but mainly with a STEM Academy of the work that involved in STEM Academy. It's been mainly in the intro-core sequences that I've been involved in. So that's kind of the focus of a lot of the work that's been done there. Um, I've been teaching for seven years full time so and part of the STEM Academy from the beginning, but last year and this year I haven't been able to participate. So I don't know how many years that was maybe four years or three. Something like that. And if you want specific number, I can look to get that spot.

[some connection issues for Elaine]

5 - Um so I'm from the college of Liberal Arts and Earth Sciences. Um I teach earth science courses. As well as geography and geology. It's a lot at in 2000 level, and then, um, A new junior, level course. So, um, Very, very similar just more environmental Studies and environmental science.

Question 2:

0 - All right, we're gonna move forward and see if we can get a better connection to Elaine and talk with her later. Um so one of the questions I wanted to post everybody uh was what motivated you to participate in this STEM Academy.

2 – Just a point of clarification, do you mean the first time or the current?

0 - either, uh either way, it works for me. Yeah. So what? Yeah, why do you want to be a part of the STEM Academy, or what motivated to be part of the STEM Academy?

2 - I mean, I'll start as I asked that question. For me, it was Because I'm in a mixed Department with social scientists and physical scientists, and a number of the physical scientists teach sort of upper levels. I started in there because I was kind of interested in talking to other physical scientists who taught at the same intro levels I did to get ideas about things like teaching big intro sections because I teach, you know, not as many anymore, but I used to teach a multiple 180 seat sections, every semester. And it was only one or two people in my department, who taught in a STEM discipline that I could talk to and I was kind of interested to get conversations with other people who were doing the same sort of thing and running into the same sort of issues. It was very similar to why for years I participated in ALA (Active Learning Academy). Except I was more interested in talking to discipline specific people. But that's for me.

1 - I'm gonna hop on that because that's, that's my experience as well. So I had done, there was an adjunct cohort that went through for the center for teaching and learning and I learned a whole bunch and I was starting to get into the active learning stuff. I went to the ALA, but they, they always recommended things that didn't feel like they applied in my discipline. So, when I heard about the STEM Academy, I was like, okay, this is Active Learning, but for me for my courses, like it's going to fit my courses better and, and really looking forward to the opportunity, like you said to collaborate with people in disciplines that weren't mine, but were like mine kind of to see what they were doing. What are you doing? So I've learned so much for my class that all came from somebody else's classroom, right? So I needed access to more classrooms.

3 - Yeah, I would say that's the reason I'm gonna keep staying here. Is that some of the best kind of information, I've gotten is just ideas for individual things that people do in the classroom. Uh, I took a teaching course for specifically for physics as part of my graduate education. And so a lot of this, you know, I was really interested to see if there's any kind of overlap there. Um, But, we also teach a class in the physics department for introductory TAs in order to make sure that our background information we were using for that was really pertinent and up-to-date and all those things. And so that's another reason that I signed up.

4 - So, yeah. Now I would say not much different than what has been already shared. Um I was you know when I first started kind of consider myself junior faculty, and looking for ways to learn, you know best practices you know how to reach students. You know my approach in philosophy is student centered and you know, from the AL also. I was participating in ALA and you know um STEM Academy seemed kind of geared towards that as well. And, you know, it

was sure, like, you know, learning from others is the best way to, you know, not fall through pitfalls and, and learn and, and grow from there. So, that was also, what motivated me to participate and continue to participate in those years, I did

[Elaine has fixed her device connection]

5 - Um, Yes, this is my third time through. I realized that I uh didn't mention that uh but very similarly to what other folks have said. Um it's just really nice to work with people who are like-minded, but are in adjacent disciplines. And the things that I never thought that I might be able to learn from a chemist or a physicist for example, you know, is really not the case. There are some things that translate very well no matter what I'm teaching, so it's just nice to nice to be with the community.

0 - Thank you. And uh how many years have you been teaching Elaine?

5 - Uh sorry uh, 22 here. Um, so about 24 in terms of job.

Question 3:

0 - Wonderful. Thank you. Um, so my next question for everybody is, um, if you were to walk into a classroom that was using evidence-based teaching practices, what kinds of things, do you think you would see and hear in that classroom? Take your time to think it through.

3 - I think that's really easy for a physics classroom. There's clearly um, kind of a kind of predict, experiment, reflect kind of thing. That's just inherent to a lot of like Active Learning things and really work well for how physics generally works as far as like what you can do in a classroom. You know, you can shoot a projectile across the room and everybody can kind of see it. Those kinds of things. Um, it's immediately different from like a lecture style classroom, so that's something that just comes to mind instantly. So, Of course, there's all kinds of other things, think-pair-share, all these kinds of other breaking into groups, which is not something you'd really ever see in a standard lectures.

1 - I would say that I would just expect to see the students doing things, saying things, talking to each other, talking to the instructor, working on something together, or working on something individually. Anything that's not them listening to a lecture I would qualify as Active Learning, right?

2 - Yeah, I think the word that comes to mind to me is “engagement”, which is kind of both what you all have described is that whether it's the students engaged with material or an experiment, or in some of my cases, it's rock samples that I've passed out or with each other that they're essentially engaged in some sort of Process or activity, and not just sort of passive receptacles, so to speak for a lecture.

4 - I guess I would just say non-traditional.

5 - Yeah, that's a good word for it. Um, Yeah. I'm not sure I have much to add to that, um, you know, just to emphasize, I want them talking to one another more than they're talking to me. In many cases and I think just giving them opportunity to Um, think, reflect, and problem solve. Um, I think, you know, those are all things that I would expect to see you know in a classroom that was evidence-based.

0 - Anything else you'd like to add?

4 - I think it just I'd probably say controlled chaos.

Question 4:

0 - Understood. All right, thank you. Um so next question that I wanted to post everybody's um I want you to describe something you learned from your time in stem Academy. Uh and how you have used it in your teaching practices.

1 - I think one thing that I learned that made me feel really comfortable. Was I learned that it's okay to try something that then didn't work. That that is not a fail. That it’s okay. I either need to modify this or do it differently. And having a supportive community to say “oh wow that really didn't work for you but But let's see if we can figure out what didn't why didn't work”, you know, to have somebody to bounce stuff off. So definitely, that's something.

2 - I mean I would say piggybacking on that. It's okay to take things from other people that they're doing and to modify it. I mean You know, I think sometimes, You know, we feel like we have to create all of this stuff. Um, And one of the things that, you know, this is true for ALA, as well that I've learned is that other people have good ideas that can be modified for things that you're doing. It's you know, you don't have to necessarily reinvent the wheel. Um, I would You know, a second, what you're saying to be about trying stuff, classrooms are experiments. You know, we teach the students to experiment. We're experimenting with how things work like, I've done three or four new assignments, in my Earth history class this semester and some of them work, some of them hadn't, you know, I always tell the students, “this is the first time I've done this. I don't know if it's going to take 30 minutes or 70 minutes. We're just gonna see how it goes”, but yeah, it's take take stuff from other people. If you see something that's good,

4 - I think maybe for me also adding to that, you know, everything that was said I can totally relate to. Also, you know, being transparent with students and trying to creating a more collaborative kind of relationship between me as an instructor and students and the content that I'm trying to deliver as well. So, Um, a lot of the, the practices, or a lot of the, the examples, and things that we've, you know, seen and adopted kind of lent that towards that. So I figured that's something I found myself over the years. Um, highlighting more and valuing more really, appreciating more as well.

5 - Um, you know, I mean, I would say, yes to everything that's been mentioned. Um, This isn't really teaching practice, so I don't know if this counts but quite honestly my interaction, particularly in STEM Academy, has improved. Uh, giving of advice. Uh, to students. So Um, because STEM Academy gives you a way to find out what your colleagues are doing and related disciplines. Um, It gives me a way to talk to students about what we're trying to accomplish. Um, and maybe help shift their perspective, just a little bit. Um, when they say, “oh this is, this is so hard and I just don't understand all of this, you know, stuff” and usually the stuff they're talking about is active learning and taking a lot of, um, Not an unreasonable amount, but a lot of responsibility. Um, and they're not used to that. And if your content is at all challenging, um, you know, that just ramps things up. So, Um, I can have better conversations with students not only about my class but about other classes that they may be taking. So that you know, for example, math classes, right statistics um is important in my discipline. Um, And talk to them about, you know, what's happening with Um, the redesign right. And chemistry is another one I spent some time talking about. So You know, that's that is a completely unexpected benefit to me. Um, so agreed.

0 - All right, anything else we'd like to add about? Um, Something that you've learned how it's an improved teaching practices.

2 - I mean, one of the things Nancy said, sort of jog something in me is, um, One of the things I was I used to be very poor at, I'm not great at it now but is the idea of letting the students know, prior to an assignment, what you want them to get out of it. Like, that's not something that I recall getting very much of when I was in school and it's something that through STEM Academy, I think, has been made a little clearer to me about the importance of this sort of setting, not just SLOs, but Just a general idea of “okay, this is why we're doing this” and Elaine talked about this a little bit, but “this is why we're doing this” and, um, getting them to understand the point of what we're doing.

Question 5:

0 - Anything else anyone would like to say? Let's go into the next one. I know you're (Bobby) brand new to itself. Haven't got the chance yet too much. All right, so next question is asking about what has been one of your biggest frustrations or barriers when implementing new teaching strategies,

1 - My students saying, “I didn't pay to teach myself.”

2 - No, I haven't gotten that one. I haven't gotten that. I mean, I've gotten. “Why are we doing this?” Yeah, you know “why?” You know. For me, it's Because I've, I've flipped a lot of my classrooms. Is getting them to do the part. That's their responsibility. And the The difficulty for me is, Holding the line in then not just teaching it to them because you know, when none of them do it we can't really do what we need to do in class so I end up just re-teaching it. So it's sort of Undercuts, the whole structure of my class is, So that's been a big frustration for me.

3 - Um, I mean, the only thing that I've really implemented that changed significantly is uh like an open-ended kind of one-on-one question. So instead of a test format it's like an interview question, kind of thing and I think they They have trouble with that interaction, just because they're not used to interacting on a one where they're kind of one-on-one, it's a very intimidating. And so, there's a little bit of pushback initially for those kinds of questions. But then after they do it once or twice, it really seems to, you know, their stress levels way down. They realize I'm not going to crucify them with any kind of response. I'm really just there to really try to better understand what it is that they're thinking. They also know they're not going to be penalized too heavily, but that's that's the only thing that I really have implemented significantly. That's changed the course where there's been pushbacks.

1 - Can I hop on that? And say that one of my difficulties is I'm having them do stuff. I would have hated as a student. I was a very good lecture student. I was not interested in working with other people in groups. So I'm having to learn to facilitate these things and sell them as “this is really good for you.” And you're, “we're going to make it to find a way to scaffold it.” It's something that I would not have chosen for myself as a student. So I'm having to defend something that I get, why they don't like it.

3 - I will definitely agree with that. Yeah, especially when it comes to like, group work, where there's larger groups and a lot of interactions Yeah, so I think at least STEM Academy is at least given me enough structure to help realize how I can formulate groups and assign. The tasks so that they all take equal ownership and that kind of thing has helped a lot. Anyway.

0 - Any other frustrations or barriers that we've experienced?

4 – Just the amount of work that goes into doing all this. Yes. You know, it's it's a lot and And because you're just trying to make it clear. Why you're doing this? You know, what are they going to get out of this and plus that it's there's a lot of pieces that they only make sense when the students do all of the pieces and if they don't miss, if they don't want to do one part, it's it's, you know, like the whole kind of story or the system kind of falls apart, and it loses as meaning and value. And try to find ways where to kind of filling the gaps or plug in and, and things like that. That's been challenging or like, you know, frustrating sometimes

2 - I guess, one other thing that I find challenging sometimes is when I do group work in class knowing that there are passengers, and I can't capture like, They're kind of getting grades. Um, through the rest of their group. And since I do a lot of informal group work. There's no questionnaires and there's no assessment between the individuals. So there's a little bit of frustration on my part about that that I know students are essentially inflating their grade through some of the process.

5 - Yeah, I think not being prepared and Yeah. So um I, I think the term that Felder and Brent used was uh, which I had not heard, I heard the social loafing thing. Uh, which I think is great. But freeloading. So, I found myself since I read that, you know, As my classes are working and

informally, reminding them, “Don't be a freeloader” And, It's hard, uh, to have conversations with people that you're not entirely certain that they want to be there. Yeah, or Why they're there in the first place. So I find myself having like one-on-one conversations, well, you know, folks are working in groups with some folks to try and Get them moving. Um, And, End up asking them, you know “what's your why?” So students, not knowing their “why” is one of my biggest barriers. I can't give him the goal if they don't have one. So I have one goal setting activity they really up probably ought to do more. That I think. Um, it's helpful because it has four quadrants where they have to think about things that You know, worry them that, they're excited about that, they've learned that they're, they've had a lot of success in. And, Um, That gives them a space to think about where they may need to work and where they You know, maybe have really, you know, done what they need to do and something that they can be proud of Um, and Sometimes that that helps a little bit with morale. My former way was, you know, “the beatings will continue”.

3 - So, something Nancy said, brought something to my mind, sorry, um, was students obsession with points at their grades, yes, rather than the learning. Um, That's always been and probably will continue to be an obstacle until they'll kind of grading system is revamped starting from pre-k.

1 - I was gonna say, coming on something Nancy said about it being a whole lot more work. It's a whole lot more work and not only do the students not appreciate the whole lot more work, but sometimes my department doesn't understand or appreciate the whole lot more work. Like they don't they don't see why I would do that thing, that is so much more work. You know, when we've always done it this way.

2 - Well, I mean in some respects that not only do the students, not appreciate that tt's more work, they think it's less work. Because you actually are like running around in the classroom less like they're used to an hour and 15 minutes where someone stands up in front and they're doing everything. Whereas, in a lot of what we do now, it's you stand up for 10 minutes or 15 minutes, and then they do the work, the rest of the class, they don't see the three weeks it took you to write what and then grade it and give feedback. So not only do they not see the work but they don't realize it's actually more work.

Question 6:

0 - All right, thank you for and so, Bouncing off a little bit of what you were saying. My next question for everybody is how would you describe the response from your peers and administrators outside of the STEM Academy to these teaching strategies that you're trying?

1 - Yeah, I think they just don't have any idea like they think. “Oh, is that newfangled, like they're putting people in groups.” You know, “we've seen we've seen changes in education before people do weird stuff, whatever, I'm gonna keep doing what I'm doing.” Um, And, and they certainly don't recompense us any for, for the time that we, you know, I mean, that's not,

that's it's on our, it's on us, we do it because we think it's important, not because they're going, “wow, you're really doing a great job, here's a promotion.” Right. They just don't know.

2 - Yeah, I mean Elaine and are in the same department, so, Elaine can correct me if she thinks I'm wrong, I just think most of the out Department doesn't understand that we do things differently or if they do they don't pay that much attention to it.

5 - Yeah, yes, I totally agree with that and there's nothing in our review structure in teaching, which is what we do, right, more so than anything else. And, There's nothing that, you know, there's a section on teaching development on my CV update, but there's nothing in the way that we're actually evaluated on teaching, except for student evaluation. So I find that to be Incredible and I have been told “stop trying to work so hard. Um, Go back to what you did before. Don't try all this new stuff” and So uh, so I've become super grumpy when it comes to annual reviews, because it's, there's no, there's no appreciation.

3 - It's almost like they're effectively saying “stop being a scientist” when they say that. Yeah. Because I'm like, no, we had, there's evidence. There's ample evidence that this kind of, okay? Anyway, I would say it's very polar in my department. So, there are people who buy in completely and most of those people have had interactions with introductory, uh, classes for significant period of time. Um, and then there are people who maybe teach summer classes and they simply just don't buy into it and they do whatever they've always done. And that there's no, there's no in between. And so, I guess we're lucky that the department head is very supportive, which is why I get to be here, so, yeah.

4 - So, I've got that polarized kind of environment, but the good thing is, leadership, is on this on our side versus. Yeah. So, um Like the, the college, you know, from the Department level, to the college, to the Dean, it's all supportive and actually pushes these type of approaches. So which is great. The, the kind of the naysayers are Unfortunately, typically the kind of the tenure-track, the research focus driven faculty that don't want to spend time doing the work, or looking at different ways of doing things. And, you know, want to just carry on with what they’ve been exposed to and how they were taught. And they, you know, unfortunately, it's very, very unfortunate because it's not just also just about the pedagogy or the evidence-based [practices]. It's also the students, right? So these type of kind of practices and activities, allow us to actually continue to understand our student population. That is always changing which, you know, it's changed over the years tt changed from one semester to another it probably changes even within during the semester. So You know, that's kind of typically what I've seen in or at least in our in our college and in my departments,

3 - Are we supposed to talk about the College of Liberal Arts and Sciences or the College of Science? How do we break that up? Now, as far as this part of the because you asked part of administration,

0 - I just said Administration Department works. Yeah, so the, it can be whoever you see as Someone who's looking into what you're doing, and yeah.

3 - Yeah, and so that's department-wide and I don't really feel like Administration has a strong influence on individual departments, as far as that goes right now.

2 - I wouldn't think so, but I don't know. I mean, I'm fortunate enough like my background is geology and It's a discipline where a lot of Hands-On stuff is pretty traditional like we still would do lectures, but lab components are always very Um, Hands-On. So, a lot of those kinds of things I'm doing in the lectures. Now, look very much like what we would traditionally do in lab. So it's not that foreign to Sort of my disciplinary peers. But, Yeah.

1 - To piggyback the tenure track versus non-tenure track thing. That's very true. It's polarized in our department. So our non-tenure track, people are out doing incredible. Things. The tenure track are doing. They're doing fine, but they're just doing it. The non-active learning way, and much more focused on. Um, research than on teaching and It seems like there's this weird cult. You know, and they're looking at us like we're some kind of weird cult.

0 - Yeah. You all are the cult?

1 - Yeah, we're the weird cult now.

Question 6a:

0 - gotcha. Um, so sort of as a follow-up to this question, I was wondering what kinds of responses. Um sort of contributed to making you feel either supported or recognized for inventing good teaching or what kind of responses would you want to see to feel supported and recognized for the practices that you're implementing?

1 - I got I got uh, nominated for an award. That was very nice. It was very nice but um, Really, I'd like to have More salary.

3 - I have kind of a smart-ass answer to that. Go ahead. Um, I would like to be able to use some other metric besides DFW rates in order to say something about the learning of students in the classroom. And so that would be I think enough. To make me feel like it's valued, right? Because then I could use that data and if that data at some point, superseded, some DFW thing that I would feel like it was valued before that it's still just, “we're improving learning. So we're really also improving The DFW rates” is how

1 - the students are great. Obsessed. So are the department heads

2 - Yes, right well and following up on that. I think. What would make me happy? You know aside from obviously everyone would like more money. But I would like, And this is similar to what Elaine was talking about. The discussion in our evaluations of teaching, to actually be a discussion of teaching and not just “Okay, you got a 4.2 on this question. That students aren't

really that well equipped to answer and you got a 4.4 on this question. That students aren't really that well equipped to answer.” That's not a measure of teaching. That's a measure. It's a Survey of whether the students enjoyed the class or not. And Yes, I would like all my students to enjoy my class but that's not a measure of their teaching and learning. It's a measure of you know, whether I created a fun environment and made them work harder than they wanted to work or not. So I would just like, at least some sort of discussion in my annual evaluations about my actual teaching and not just these surveys. Which are being revamped And I've seen the early draft and they’re No better.

0 - Anything else you'd like to hear? What kind of things make you feel supporter recognized for implementing your teaching practices?

4 - Maybe not put so much emphasis on the few that are, you know, like the naysayers for even from the students, right? Like so even of course evaluations or the few students that will send an email to the Dean complaining that. Yeah, “she hasn't taught me anything I have to teach myself, I have to do all the work” when they are the minority like the smaller percentage of students that go through the course. And expect that to be like, yeah, well we're not going to please anybody and we'll continue to do what we're doing and and do what we think is is right and we feel Um, fits our our approach or philosophy and, you know, they're either join or, you know, find somewhere else to go. I Guess, right. Um, but we, you know, at least sometimes if I, um, Kind of emphasize that or re-echo the few that, you know That make the loudest noise, right? But they're just a few compared to the majority that went through the course. And you know, did have a positive experience that actually did have a good learning outcome regardless of right? Like you know the DFW right and all of that. But they actually did learn um something that they can you know utilize and continue on.

5 - Yeah, I think, you know, I get more recognition externally. Um, outside of the University. Then I do internally within the university. Um, Uh, I think our metrics are Screwed up. And I think because a lot of them are based on. [something] Easily quantifiable, Which doesn't mean that it's a good measure. And, In the last. So not counting this Academic Year. But for like the previous four, the only time I heard from my department chair about my teaching was when they got emails about you know my big issue is I'm a very I'm very slowly grading. And students that want instant gratification Expect me to move much faster. Um, so I only hear when it's a negative right? Which is what Nancy was talking about you know, other folks have been talking about Um, and so I'd love to see a change there. And I, I obviously I agree with Peter, that I wouldn't really, like there to be A, uh, I don't know what the word is, I'm going to say “serious” Look at what I'm doing. Um, in the classroom. And how that how would I do To change my practice to home this skill, right? So things like STEM Academy. Um, Aid in my professional development. Like I said, I'm super grumpy and I just feel right now, right? Like Everybody wants smart people to work for them. But nobody wants to Trust the professionals to do it and nobody wants to, you know, To provide the resources, whether that's more money or, you know,

More stuff in the classroom, you know. I shouldn't The the main change in my classroom that I teach in right now, the most is that I have white boards instead of chalk boards. And I mean,

0 - All right, thank you. Um, Anything else I would like to add about? Our outside perspectives. Or I think we've all worked ourselves up.

2 - I mean part of what Elaine said is true. The only time he most of us hear about teaching is if something goes wrong.

1 - I honestly think that's all the department cares. Like as long as there's no complaints.

2 - Yeah it's the squeaky-wheel-syndrome. Yeah. Okay and you and you look at how research is treated. It's treated in a very different way. It's all celebratory, whereas teaching the focus is And it's gonna get even worse with how the legislature has changed funding models. But it's basically, Get rid of the DFWs, move them on. I don't want to hear any complaints from your classroom, but so and so publishes a Great paper. Yeah, and it's the two aspects of our job and they're approached very differently. One is a very, "let's eliminate mistakes", and mistakes mean different things. The other is, "let's celebrate, who's doing well." You know.

Question 7:

0 - All right. So um Just to have a couple more questions here. I wanted to know what aspect of STEM Academy has been the most impactful for your professional development.

1 - Okay, I have a really easy answer to this one. Our department was having trouble with our TAs. We were unleashing them into the classroom with no training whatsoever and as predictably happened, we had lots of problems. So Um, I stepped in and said I think we should train our graduate students and I used the STEM Academy as my model, for how to train graduate students. And we use [Felder and Brent book] is our textbook. And so that's been That's been huge for me. I mean, like, now I'm part of The Graduate faculty now because I did STEM Academy and thought, "hey, this is a good book."

[side conversation about how the TA training works]

2 - I mean, I would say. Just interacting with other people who are I think I forget who used the term but discipline adjacent, you know, I was part of the ALA for a number of years and I enjoyed it. But what really the real Limitation for ALA for me was usually what would happen is I'd end up in a group with a couple people from the humanities and a couple of social scientists who were on the social side, you know? And we would talk about things and they would frequently talk about stuff that just really I'd say, "yeah, that's great, I can't do that." You know, there's not a way for me Do that in my class because a lot of times what they were talking about are issues where there isn't technically a right answer, where it's very much you know, either ethical or philosophical or whatever. And we well I have those issues in my classes, 95% of what I do is, "yeah, we have to find this answer." Um, and so the best thing about STEM Academy for

me, has been taking People who have the same sort of mentality about teaching as those involved in ALA but who are disciplinary adjacent and who I think Grace said you know, understand the problems that I'm dealing with that are very specific to how my classes work. Um And just tapping into that group of people who have great ideas and have the same interests as I do. And understand the problems in sort of the same way I do is very helpful.

0 - You guys have something that was most impactful for the professional development that they got from STEM Academy.

4 - I definitely agree, right? Like with the mind like it like people but they're not necessarily in your discipline. So having you know, a lot of our meetings, you know, sharing ideas and examples, and “here's what I've done.” And just getting that feedback and incorporating that external perspective has been Um you know, always helpful but the one thing that I, you know, from the beginning, the practice that I kind of learned and valued tremendously is the outcome, learning outcome or learning objective of whatever activity or thing I have. And my course is making sure that I truly think about that is like “what do I want them, You know to get out of it.” “Why is it like and where does it fit in the big picture?” And um Every single thing that, you know, we do in the class from, you know, like module objective, activity, assignment objective, you know. Um, just making sure that everything is purposeful yes, making that clear. Um, and that was like, from the thing that was like the first thing. STEM Academy has us think about, writing learning objectives. And, uh, And just how to think about those and how to word them and all of that. And, you know, I think that was very, very helpful.

5 - Yeah, yeah. Having to take the CTL workshop on learning objectives was was quite helpful. Um, and it was helpful and every single class um and and getting to that have that kind of alignment, I think. Um, is very important. Very best ALA experience that I had was when they put us together with other STEM Academy members. That was the very best team that I ever worked with and that Nancy was on it. Um, But um, I think, because partly, because we already had this sort of Rapport and relationship from STEM Academy, but We all kind of also knew Our purpose, you know, for What we wanted to work on. So it wasn't some sort of You know, weird random thing. Um, That sometimes can happen. Um but you know, when we had an idea on something and then we all Contributed different aspects of it. And that's, I think that's, that's kind of STEM Academy in a nutshell. We all have like, the central purpose, like, you know, focusing on reading the Felder and Brent book, right? But we're all getting different things out of it. And, um, And I really benefit from hearing what other people are doing and, and getting. Any time that you can have a dedicated time to think about your teaching. Um, and have other people around you. So that you can You know, socially right? Um, Is is a gift. Um, So, on this campus. This is where I come. To get. A boost. Yeah. So that's the most impactful thing. Uh, I think for me is, is the benefits to me and my attitude toward teaching, uh, when I get to come and see folks, From STEM Academy.

1 - Plus now, I know people across campus, it was cool, right? Like I know people in physics and earth science. And It's worthwhile.

Question 8:

0 - Well thank you all so much for being honest with me and giving a lot of great information. My last question is just, is there anything else you'd like to mention that we haven't discussed?

1 - Say, I really appreciate Tonya and Kathy for doing this. Giving us this Outlet.

2 - Yeah I agree. I think they I suspect I could be wrong but you know, they were Members of ALA. And I suspect, they felt very much like what a lot of us have, expressed that ALA was great, but It sometimes seemed like it didn't quite fit. Um, You know, our disciplines and and I think they've done a very good service to the university in creating this.

3 - I'm happy to say that. I haven't had that experience, so that shows you how good much difference there is in STEM Academy, right? Because I've never, as soon as you said that I was like, oh, that makes sense. But I just haven't had that since I've been here because every every example that everyone has given is something I'm just, “oh yeah, You have to do this for that thing” Yeah. And so it's, it's been great. Yeah.

0 - Anything else we'd like to add?

5 - I don't think so. It's, you know, they need to continue to fund it. ALA got taken away from us. Um and so you know, or at least temporarily. Uh, and you know, there's just way too much value that we get from this. Um that it really needs to with this, you know, needs to be funded at an appropriate level. Um, to keep This forward motion.

1 - I'd like to get the people in my department who are not interested to come. Like I want them to participate, right? We have actually.

2 - I mean we had people who you're looking pretty good cohorts.

1 - Yeah. And we had people who were like, what is active learning who are now advocates for active learning. So More more, more people.

Appendix B – SVSM Final Paper Rubric

SVSM Final Paper Rubric

Read each paper and select the rating that best matches the work shown in each of the five categories in the rubric.

Paper Element	Superior (5)	Excellent (4)	Proficient (3)
Literature Review	Literature Review shows the author's deep knowledge on at least three BINSs. The explanation is exceptionally thorough, accurate, and uses many reputable citations.	Literature Review shows the author's deep knowledge on at least two BINSs. The explanation is very thorough, accurate, and uses several reputable citations.	Literature Review shows the author's knowledge on at least two BINSs. The explanation is thorough, accurate, and uses a few reputable citations.
Research Question	Research question is based on at least two BINSs. The research question is very clearly stated. The research question is very innovative and based on exceptional understanding of existing knowledge in the literature.	Research question is based on at least two BINSs. The research question is clearly stated. The research question is very innovative and based on deep understanding of existing knowledge in the literature.	Research question is based on at least one BINS. The research question is clearly stated. The research question is innovative and based on understanding of existing knowledge in the literature.
Procedure and Data Collection	Experimental design addresses the research question very well. Experimental design identifies variables and controls. Experiment is run with an exceptional number of trials and is reproducible.	Experimental design addresses the research question well. Experimental design identifies variables and controls. Experiment is run with a sufficient number of trials and is reproducible.	Experimental design is appropriate for addressing the research question. Experimental design identifies variables and controls. Experiment is run with a sufficient number of trials and is reproducible.
Conclusion and Discussion	Logical conclusion that is very relevant to the research question and the results of the experiment. Exceptional explanation of limitations and significance of results. Shows exceptional understanding of at least two BINSs.	Logical conclusion that is very relevant to the research question and the results of the experiment. Thoroughly explains limitations and significance of results. Shows deep understanding of at least two BINSs.	Logical conclusion that is relevant to the research question and the results of the experiment. Explains limitations and significance of results. Shows understanding of at least two BINSs.

Paper Element	**Satisfactory (2)**	**Unsatisfactory (1)**
Literature Review	Literature Review shows the author's knowledge on at least two BINSs, or the explanation is somewhat thorough, mostly accurate, and uses a few reputable citations.	Literature Review shows the author's knowledge on at least one BINS, orr the explanation is not thorough, or accurate, and does not use reputable citations
Research Question	Research question is somewhat based on at least one BINS, or the research question is not clearly stated, or the research question is somewhat innovative and based on understanding of existing knowledge in the literature.	Research question is not based on at least one BINS, or the research question is not clearly stated, or the research question is not innovative or not based on understanding of existing knowledge in the literature.
Procedure and Data Collection	Experimental design is somewhat appropriate for addressing the research question, or the experimental design identifies some variables and controls, or the experiment is run with a sufficient number of trials and is somewhat reproducible.	Experimental design is not appropriate for addressing the research question, or the experimental design identifies some variables and controls, or the experiment is run with an insufficient number of trials and is not reproducible.
Conclusion and Discussion	Logical conclusion that is somewhat relevant to the research question and the results of experiment, or it explains some of the limitations and significance of results, or it shows some understanding of at least one BINS.	Conclusion is not logical or does not relate to the research question and results of the experiment, or there is little to no explanation of the limitations and significance of results, or it shows little to no understanding of at least one BINS.

Appendix C – Complete Rubric Grading Data for SVSM Final Papers and Complete Mann-Whitney U Test Data

		Rubric Category																			
	Subject Number	Literature Review (LR)				Research Question (RQ)				Procedure and Data Collection (PDC)				Conclusion and Discussion (CD)				Total Score (TS)			
	Reviewer:	A	B	C	LR mean	A	B	C	RQ mean	A	B	C	PDC mean	A	B	C	CD mean	A	B	C	Ts mean
Cohort 1	1 and 2	4	4	3	3.67	4	3	3	3.33	4	4	4	4.00	4	4	3	3.67	16	15	13	14.67
	3 and 4	4	4	4	4.00	4	4	3	3.67	5	5	5	5.00	4	3	3	3.33	17	16	15	16.00
	5	3	3	3	3.00	4	4	4	4.00	4	4	4	4.00	3	3	2	2.67	14	14	13	13.67
	6	3	3	2	2.67	3	2	2	2.33	3	3	3	3.00	3	2	2	2.33	12	10	9	10.33
	7	4	4	4	4.00	3	2	2	2.33	3	4	4	3.67	3	2	3	2.67	13	12	13	12.67
	8	2	2	2	2.00	2	2	1	1.67	3	3	2	2.67	3	4	3	3.33	10	11	8	9.67
	9	2	2	2	2.00	3	3	3	3.00	2	2	1	1.67	2	3	3	2.67	9	10	9	9.33
	10	3	2	2	2.33	1	2	2	1.67	2	2	2	2.00	2	2	2	2.00	8	8	8	8.00
	11	2	3	2	2.33	2	2	2	2.00	2	2	2	2.00	3	2	2	2.33	9	9	8	8.67
	12	2	2	2	2.00	2	2	2	2.00	1	2	1	1.33	1	2	2	1.67	6	8	7	7.00
	13	3	4	4	3.67	2	2	2	2.00	2	2	1	1.67	1	2	1	1.33	8	10	8	8.67
	14	2	3	3	2.67	2	2	2	2.00	4	3	3	3.33	2	3	3	2.67	10	11	11	10.67
	15	3	3	3	3.00	4	3	3	3.33	5	4	4	4.33	4	4	4	4.00	16	14	14	14.67
		Total LR mean	Total LR mean std. error	Adj LR mean	Adj LR mean std. error	Total RQ Mean	Total RQ mean std. error	Adj RQ mean	Adj RQ mean std. error	Total PDC mean	Total PDC mean std. error	Adj PDC mean	Adj PDC mean std. error	Total CD mean	Total CD mean std. error	Adj CD mean	Adj CD mean std. error	Total TS mean	Total TS mean std. error	Adj TS mean	Adj TS mean std. error
		2.87	0.21	2.70	0.20	2.56	0.22	2.39	0.22	2.97	0.33	2.70	0.31	2.67	0.21	2.52	0.22	11.38	0.81	10.30	0.73
Cohort 2	16	4	4	5	4.33	4	3	4	3.67	4	5	4	4.33	4	4	4	4.00	16	16	17	16.33
	17	3	3	4	3.33	4	5	4	4.33	4	4	4	4.00	3	3	4	3.33	14	15	16	15.00
	18	3	2	2	2.33	3	2	3	2.67	3	4	3	3.33	3	4	3	3.33	12	12	11	11.67
	19	4	3	4	3.67	4	3	4	3.67	4	4	4	4.00	3	3	3	3.00	15	13	15	14.33
	20	2	2	2	2.00	3	3	2	2.67	2	3	2	2.33	2	3	2	2.33	9	11	8	9.33
	21	4	4	4	4.00	4	3	3	3.33	4	4	4	4.00	3	3	3	3.00	15	14	14	14.33
	22	4	4	4	4.00	4	4	5	4.33	5	5	5	5.00	4	4	5	4.33	17	17	19	17.67
	23	1	1	1	1.00	2	1	2	1.67	3	3	3	3.00	3	3	2	2.67	9	8	8	8.33
	24	3	3	2	2.67	3	3	3	3.00	3	3	4	3.33	2	3	3	2.67	11	12	12	11.67
	25	4	4	3	3.67	3	3	3	3.00	4	4	3	3.67	4	4	4	4.00	15	15	13	14.33
	26	3	3	2	2.67	4	4	4	4.00	4	3	3	3.33	3	4	3	3.33	14	14	12	13.33
	27	4	5	4	4.33	3	3	3	3.00	4	4	3	3.67	4	4	4	4.00	15	16	14	15.00
		Total LR mean	Total LR mean std. error			Total RQ Mean	Total RQ mean std. error			Total PDC mean	Total PDC mean std. error			Total CD mean	Total CD mean std. error			Total TS mean	Total TS mean std. error		
		3.17	0.30			3.28	0.22			3.67	0.20			3.33	0.18			13.44	0.79		

Mann-Whitney Test - All Papers						
Category	G1- N	G2 - N	G1 - Mean Rank	G2 - Mean Rank	Exact Sig (2-tailed)	U
Literature Review	13	12	11.58	14.54	0.319	59.5
Research Questions	13	12	10.23	16.00	0.049	42.0
Procedure and Data Collection	13	12	10.92	15.25	0.145	51.0
Conclusion and Discussion	13	12	10.04	16.21	0.033	39.5
Total Score	13	12	10.42	15.79	0.069	44.5
Mann-Whitney Test – Individual Papers Only						
Category	G1- N	G2 - N	G1 - Mean Rank	G2 - Mean Rank	Exact Sig (2-tailed)	U
Literature Review	11	12	9.95	13.88	0.17	43.5
Research Questions	11	12	8.50	15.21	0.016	27.5
Procedure and Data Collection	11	12	8.82	14.92	0.029	31.0
Conclusion and Discussion	11	12	8.27	15.42	0.009	25.0
Total Score	11	12	8.41	15.29	0.013	26.5

Appendix D – Student Attitudes towards STEM Survey Questions

Answer Choices for Math, Science, Engineering and Technology, and 21st Century Learning Sections: Strongly Disagree (1), Disagree (2), Neither Agree nor Disagree (3), Agree (4), Strongly Agree (5)

Math

1. Math has been my worst subject.

2. I would consider choosing a career that uses math.

3. Math is hard for me.

4. I am the type of student to do well in math.

5. I can handle most subjects well, but I cannot do a good job with math.

6. I am sure I could do advanced work in math.

7. I can get good grades in math.

8. I am good at math.

Science

1. I am sure of myself when I do science.

2. I would consider a career in science.

3. I expect to use science when I get out of school.

4. Knowing science will help me earn a living.

5. I will need science for my future work.

6. I know I can do well in science.

7. Science will be important to me in my life’s work.

8. I can handle most subjects well, but I cannot do a good job with science.

9. I am sure I could do advanced work in science.

Engineering and Technology
Please read this paragraph before you answer the question: Engineers use math, science, and creativity to research and solve problems that improve everyone's life and to invent new products. There are many different types of engineering, such as chemical, electrical, computer, mechanical, civil, environmental, and biomedical. Engineers design and improve things like bridges, cars, fabrics, foods, and virtual reality amusement parks. Technologists implement the designs that engineers develop; they build, test, and maintain products and processes.

1. I like to imagine creating new products.

2. If I learn engineering, then I can improve things that people use every day.

3. I am good at building and fixing things.

4. I am interested in what makes machines work.

5. Designing products or structures will be important for my future work.

6. I am curious about how electronics work.

7. I would like to use creativity and innovation in my future work.

8. Knowing how to use math and science together will allow me to invent useful things.

9. I believe I can be successful in a career in engineering.

21st Century Learning:

1. I am confident I can lead others to accomplish a goal.

2. I am confident I can encourage others to do their best.

3. I am confident I can produce high quality work.

4. I am confident I can respect the differences of my peers.

5. I am confident I can help my peers.

6. I am confident I can include others' perspectives when making decisions.

7. I am confident I can make changes when things do not go as planned.

8. I am confident I can set my own learning goals.

9. I am confident I can manage my time wisely when working on my own.

10. When I have many assignments, I can choose which ones need to be done first.

11. I am confident I can work well with students from different backgrounds.

Your Future:

Here are descriptions of subject areas that involve math, science, engineering and/or technology, and lists of jobs connected to each subject area. As you read the list below, you will know how interested you are in the subject and the jobs. Fill in the circle that relates to how interested you are. There are no “right” or “wrong” answers. The only correct responses are those that are true for you.
Answer Choices: Not at all interested (1), not so interested (2), interested (3), very interested (4)

1. Physics: is the study of basic laws governing the motion, energy, structure, and interactions of matter. This can include studying the nature of the universe (aviation engineer, alternative energy technician, lab technician, physicist, astronomer).

2. Environmental Work: involves learning about physical and biological processes that govern nature and working to improve the environment. This includes finding and designing solutions to problems like pollution, reusing waste and recycling. (pollution control analyst, environmental engineer or scientist, erosion control specialist, energy systems engineer and maintenance technician).

3. Biology and Zoology: involve the study of living organisms (such as plants and animals) and the processes of life. This includes working with farm animals and in areas like nutrition and breeding. (biological technician, biological scientist, plant breeder, crop lab technician, animal scientist, geneticist, zoologist)

4. Veterinary Work: involves the science of preventing or treating disease in animals. (veterinary assistant, veterinarian, livestock producer, animal caretaker)

5. Mathematics: is the science of numbers and their operations. It involves computation, algorithms and theory used to solve problems and summarize data. (accountant, applied mathematician, economist, financial analyst, mathematician, statistician, market researcher, stock market analyst)

6. Medicine: involves maintaining health and preventing and treating disease. (physician’s assistant, nurse, doctor, nutritionist, emergency medical technician, physical therapist, dentist)

7. Earth Science: is the study of earth, including the air, land, and ocean. (geologist, weather forecaster, archaeologist, geoscientist)

8. Computer Science: consists of the development and testing of computer systems, designing new programs and helping others to use computers. (computer support specialist, computer programmer, computer and network technician, gaming designer, computer software engineer, information technology specialist)

9. Medical Science: involves researching human disease and working to find new solutions to human health problems. (clinical laboratory technologist, medical scientist, biomedical engineer, epidemiologist, pharmacologist)

10. Chemistry: uses math and experiments to search for new chemicals, and to study the structure of matter and how it behaves. (chemical technician, chemist, chemical engineer)

11. Energy: involves the study and generation of power, such as heat or electricity. (electrician, electrical engineer, heating, ventilation, and air conditioning (HVAC) technician, nuclear engineer, systems engineer, alternative energy systems installer or technician)

12. Engineering: involves designing, testing, and manufacturing new products (like machines, bridges, buildings, and electronics) through the use of math, science, and computers. (civil, industrial, agricultural, or mechanical engineers, welder, auto-mechanic, engineering technician, construction manager)

About Yourself:

In the following series of questions, you will skip certain questions based on how you answered previous questions.
Answer Choices: Not Very Well (1), Ok/Pretty Well (2), Very Well (3)

1. How well do you expect to do this year in your: - English/Language Arts Class?

2. How well do you expect to do this year in your: - Math Class?

3. How well do you expect to do this year in your: - Science Class?

Answer Choices: Yes (3), No (1), Not Sure (2)

4. In the future, do you plan to take advanced classes in: - Mathematics?

5. In the future, do you plan to take advanced classes in: - Science?

6. More about you. - Do you know any adults who work as scientists?

7. More about you. - Do you know any adults who work as engineers?

8. More about you. - Do you know any adults who work as mathematicians?

9. More about you. - Do you know any adults who work as technologists?

Appendix E – Complete Data Tables for Two-Way ANOVA Test

	S-STEM Suvery Restuls for all Math Items																				
	Main Effect of Intervention						Main Effect of Group						Intervention X Group								
Item	Pre Survey Mean	Pre Survey Std. Error	Post Survey Mean	Post Survey Std. Error	Pre vs. Post Sig.	f-value	C1 Mean	C1 Std. Error	C2 Mean	C2 Std. Error	C1 vs. C2 Sig.	f-value	C1 Pre Survey Mean	C1 Pre Survey Std. Error	C1 Post Survey Mean	C1 Post Survey Std. Error	C2 Pre Survey Mean	C2 Pre Survey Std. Error	C2 Post Survey Mean	C2 Post Survey Std. Error	Intervention X Cohort Sig.	f-value
Math1	1.38	0.14	1.54	0.17	0.11	2.89	1.27	0.19	1.64	0.23	0.23	1.55	1.18	0.17	1.36	0.21	1.57	0.22	1.71	0.27	0.84	0.04
Math2	3.83	0.25	3.82	0.27	0.96	0.00	3.86	0.28	3.79	0.35	0.86	0.03	4.09	0.31	3.64	0.34	3.57	0.39	4.00	0.43	0.13	2.61
Math3	1.82	0.16	1.82	0.21	1.00	0.00	1.64	0.22	2.00	0.28	0.32	1.06	1.64	0.19	1.64	0.27	2.00	0.24	2.00	0.34	1.00	0.00
Math4	4.51	0.19	4.40	0.21	0.60	0.29	4.55	0.21	4.36	0.27	0.59	0.30	4.73	0.23	4.36	0.26	4.29	0.29	4.43	0.33	0.23	1.54
Math5	1.70	0.19	1.49	0.17	0.14	2.35	1.41	0.20	1.79	0.26	0.27	1.32	1.55	0.23	1.27	0.21	1.86	0.29	1.71	0.26	0.64	0.23
Math6	3.97	0.23	4.21	0.20	0.20	1.83	4.32	0.24	3.86	0.31	0.26	1.39	4.36	0.29	4.27	0.25	3.57	0.36	4.14	0.31	0.08	3.48
Math7	4.36	0.23	4.79	0.11	0.08	3.39	4.73	0.17	4.43	0.21	0.28	1.25	4.73	0.28	4.73	0.13	4.00	0.36	4.86	0.17	0.08	3.39
Math8	4.51	0.14	4.49	0.20	0.91	0.01	4.64	0.18	4.36	0.23	0.36	0.90	4.73	0.18	4.55	0.24	4.29	0.22	4.43	0.31	0.37	0.85

	S-STEM Survey Results for all Science Items																				
	Main Effect of Intervention						Main Effect of Group						Intervention X Group								
Item	Pre Survey Mean	Pre Survey Std. Error	Post Survey Mean	Post Survey Std. Error	Pre vs. Post Sig.	f-value	C1 Mean	C1 Std. Error	C2 Mean	C2 Std. Error	C1 vs. C2 Sig.	f-value	C1 Pre Survey Mean	C1 Pre Survey Std. Error	C1 Post Survey Mean	C1 Post Survey Std. Error	C2 Pre Survey Mean	C2 Pre Survey Std. Error	C2 Post Survey Mean	C2 Post Survey Std. Error	Intervention X Cohort Sig.	f-value
Sci1	4.44	0.15	4.37	0.19	0.49	0.49	4.46	0.21	4.36	0.26	0.77	0.09	4.46	0.19	4.46	0.24	4.43	0.24	4.29	0.30	0.49	0.49
Sci2	4.84	0.10	4.81	0.09	0.75	0.11	4.86	0.11	4.79	0.13	0.65	0.21	4.82	0.12	4.91	0.12	4.86	0.15	4.71	0.14	0.17	2.12
Sci3	4.44	0.23	4.62	0.16	0.23	1.53	4.77	0.23	4.29	0.29	0.21	1.69	4.73	0.29	4.82	0.20	4.14	0.37	4.43	0.26	0.53	0.41
Sci4	4.53	0.22	4.62	0.14	0.53	0.41	4.86	0.21	4.29	0.27	0.11	2.87	4.91	0.28	4.82	0.17	4.14	0.35	4.43	0.22	0.23	1.53
Sci5	4.55	0.25	4.62	0.16	0.60	0.29	4.82	0.25	4.36	0.31	0.27	1.32	4.82	0.31	4.82	0.20	4.29	0.39	4.43	0.26	0.60	0.29
Sci6	4.36	0.23	4.70	0.11	0.20	1.81	4.77	0.16	4.29	0.20	0.08	3.52	4.73	0.28	4.82	0.14	4.00	0.36	4.57	0.17	0.34	0.95
Sci7	4.53	0.22	4.79	0.14	0.27	1.29	4.82	0.18	4.50	0.22	0.28	1.23	4.91	0.28	4.73	0.17	4.14	0.35	4.86	0.21	0.07	3.65
Sci8	1.49	0.19	1.42	0.15	0.22	1.63	1.27	0.21	1.64	0.26	0.28	1.24	1.27	0.23	1.27	0.18	1.71	0.29	1.57	0.23	0.22	1.63
Sci9	4.33	0.27	4.68	0.15	0.19	1.88	4.50	0.22	4.50	0.28	1.00	0.00	4.36	0.34	4.64	0.18	4.29	0.42	4.71	0.23	0.76	0.09

	S-STEM Survey Results for all Engineering and Technology Items																				
	Main Effect of Intervention						Main Effect of Group						Intervention X Group								
Item	Pre Survey Mean	Pre Survey Std. Error	Post Survey Mean	Post Survey Std. Error	Pre vs. Post Sig.	f-value	C1 Mean	C1 Std. Error	C2 Mean	C2 Std. Error	C1 vs. C2 Sig.	f-value	C1 Pre Survey Mean	C1 Pre Survey Std. Error	C1 Post Survey Mean	C1 Post Survey Std. Error	C2 Pre Survey Mean	C2 Pre Survey Std. Error	C2 Post Survey Mean	C2 Post Survey Std. Error	Intervention X Cohort Sig.	f-value
ET1	4.47	0.19	4.35	0.23	0.58	0.32	4.32	0.23	4.50	0.29	0.63	0.25	4.36	0.24	4.27	0.28	4.57	0.30	4.43	0.35	0.90	0.02
ET2	4.61	0.11	4.31	0.17	0.08	3.42	4.41	0.16	4.57	0.20	0.54	0.39	4.36	0.14	4.46	0.22	4.86	0.17	4.29	0.27	0.02	6.49
ET3	4.23	0.25	4.12	0.21	0.50	0.48	4.14	0.27	4.21	0.33	0.86	0.03	4.18	0.31	4.09	0.26	4.29	0.39	4.14	0.32	0.88	0.02
ET4	4.47	0.21	4.45	0.22	0.90	0.02	4.27	0.25	4.64	0.31	0.37	0.85	4.36	0.26	4.18	0.27	4.57	0.33	4.71	0.34	0.31	1.11
ET5	3.86	0.30	3.98	0.29	0.70	0.16	3.77	0.31	4.07	0.39	0.56	0.35	3.73	0.37	3.82	0.36	4.00	0.47	4.14	0.45	0.93	0.01
ET6	4.35	0.19	4.33	0.23	0.89	0.02	4.32	0.23	4.36	0.29	0.92	0.01	4.27	0.24	4.36	0.28	4.43	0.30	4.29	0.35	0.55	0.38
ET7	4.77	106.00	4.65	0.15	0.43	0.65	4.77	0.13	4.64	0.17	0.55	0.38	4.82	0.13	4.73	0.18	4.71	0.17	4.57	0.23	0.86	0.03
ET8	4.60	0.15	4.67	0.10	0.60	0.29	4.91	0.14	4.36	0.17	0.02	6.38	4.91	0.19	4.91	0.12	4.29	0.24	4.43	0.15	0.60	0.29
ET9	3.93	0.31	4.14	0.21	0.36	0.91	4.14	0.30	3.93	0.38	0.68	0.18	4.00	0.39	4.27	0.26	3.86	0.49	4.00	0.33	0.77	0.09

	S-STEM Survey Results for all 21st Century Learning Items																				
	Main Effect of Intervention						Main Effect of Group						Intervention Group								
Item	Pre Survey Mean	Pre Survey Std. Error	Post Survey Mean	Post Survey Std. Error	Pre vs. Post Sig.	f-value	C1 Mean	C1 Std. Error	C2 Mean	C2 Std. Error	C1 vs. C2 Sig.	f-value	C1 Pre Survey Mean	C1 Pre Survey Std. Error	C1 Post Survey Mean	C1 Post Survey Std. Error	C2 Pre Survey Mean	C2 Pre Survey Std. Error	C2 Post Survey Mean	C2 Post Survey Std. Error	Intervention X Cohort Sig.	f-value
Cent1	4.46	0.19	4.70	0.11	0.17	2.12	4.73	0.17	4.43	0.21	0.28	1.25	4.64	0.24	4.82	0.14	4.29	0.30	4.57	0.17	0.75	0.11
Cent2	4.67	0.18	4.53	0.13	0.49	0.50	4.77	0.15	4.43	0.19	0.17	2.08	4.91	0.22	4.64	0.16	4.43	0.28	4.43	0.20	0.49	0.50
Cent3	4.84	0.10	4.81	0.09	0.83	0.05	4.86	0.09	4.79	0.12	0.60	0.28	4.82	0.12	4.91	0.12	4.86	149.00	4.71	0.14	0.33	0.99
Cent4	4.75	0.12	4.70	0.15	0.81	0.06	4.86	0.10	4.58	0.14	0.13	2.61	5.00	0.15	4.73	0.18	4.50	0.20	4.67	0.25	0.33	1.02
Cent5	4.58	0.17	4.79	0.11	0.27	1.29	4.73	0.13	4.64	0.17	0.69	0.16	4.73	0.21	4.73	0.13	4.43	0.27	4.86	0.17	0.27	1.29
Cent6	4.62	0.11	4.70	0.11	0.60	0.29	4.82	0.11	4.50	0.14	0.09	3.24	4.82	0.14	4.82	0.14	4.43	0.17	4.57	0.17	0.60	0.29
Cent7	4.71	0.12	4.58	0.17	0.38	0.82	4.86	0.16	4.43	0.20	0.10	3.04	5.00	0.15	4.73	0.21	4.43	0.18	4.43	0.27	0.38	0.82
Cent8	4.68	0.12	4.61	0.19	0.69	0.16	4.50	0.17	4.79	0.21	0.30	1.13	4.64	0.15	4.36	0.23	4.71	0.19	4.86	0.29	0.21	1.68
Cent9	4.37	0.23	4.42	0.19	0.78	0.08	4.50	0.24	4.29	0.31	0.59	0.30	4.46	0.28	4.55	0.24	4.29	0.36	4.29	0.30	0.78	0.08
Cent10	4.39	0.19	4.44	0.16	0.74	0.12	4.68	0.20	4.14	0.25	0.11	2.84	4.64	0.23	4.73	0.20	4.14	0.29	4.14	0.25	0.74	0.12
Cent11	4.70	0.11	4.84	0.10	0.33	1.03	4.82	0.09	4.71	0.12	0.50	0.47	4.82	0.14	4.82	0.12	4.57	0.17	4.86	0.15	0.33	1.03

	S-STEM Survey Results for all Your Future Items																				
	Main Effect of Intervention						Main Effect of Group						Intervention X Group								
Item	Pre Survey Mean	Pre Survey Std. Error	Post Survey Mean	Post Survey Std. Error	Pre vs. Post Sig.	f-value	C1 Mean	C1 Std. Error	C2 Mean	C2 Std. Error	C1 vs. C2 Sig.	f-value	C1 Pre Survey Mean	C1 Pre Survey Std. Error	C1 Post Survey Mean	C1 Post Survey Std. Error	C2 Pre Survey Mean	C2 Pre Survey Std. Error	C2 Post Survey Mean	C2 Post Survey Std. Error	Intervention X Cohort Sig.	f-value
YF1	2.75	0.24	3.12	0.22	0.12	2.65	2.86	0.25	3.00	0.31	0.74	0.12	2.64	0.30	3.09	0.28	2.86	0.37	3.14	0.35	0.72	0.14
YF2	2.58	0.15	2.79	0.22	0.22	1.63	2.73	0.21	2.64	0.26	0.80	0.07	2.73	0.18	2.73	0.27	2.43	0.23	2.86	0.34	0.22	1.63
YF3	2.64	0.20	3.05	0.24	0.07	3.94	2.91	0.24	2.79	0.30	0.76	0.10	3.00	0.26	2.82	0.29	2.29	0.32	3.29	0.37	0.01	8.22
YF4	1.93	0.23	2.47	0.19	0.01	9.14	2.05	0.24	2.36	0.30	0.43	0.66	2.00	0.29	2.09	0.24	1.86	0.36	2.86	0.30	0.02	6.35
YF5	2.60	0.27	2.88	0.19	0.23	1.57	2.77	0.26	2.71	0.32	0.89	0.02	2.64	0.34	2.91	0.24	2.57	0.43	2.86	0.30	0.98	0.00
YF6	2.88	0.30	2.88	0.32	1.00	0.00	2.91	0.38	2.86	0.48	0.93	0.01	2.91	0.37	2.91	0.40	2.86	0.46	2.86	0.50	1.00	0.00
YF7	2.14	0.17	2.26	0.18	0.39	0.78	2.18	0.20	2.21	0.25	0.92	0.01	2.27	0.22	2.09	0.22	2.00	0.27	2.43	0.28	0.04	4.77
YF8	2.68	0.30	2.60	0.27	0.60	0.29	2.64	0.35	2.64	0.43	0.99	0.00	2.64	0.37	2.64	0.34	2.71	0.46	2.57	0.43	0.60	0.29
YF9	3.25	0.20	3.33	0.21	0.22	1.63	3.36	0.26	3.21	0.32	0.72	0.13	3.36	0.26	3.36	0.26	3.14	0.32	3.29	0.33	0.22	1.63
YF10	3.16	0.20	3.47	0.16	0.13	2.62	3.70	0.20	2.93	0.24	0.02	6.32	3.60	0.26	3.80	0.21	2.71	0.31	3.14	0.25	0.57	0.35
YF11	2.86	0.29	2.78	0.17	0.77	0.09	2.64	0.21	3.00	0.33	0.38	0.81	2.55	0.34	2.73	0.21	3.17	0.47	2.83	0.28	0.33	1.03
YF12	3.28	0.24	3.26	0.22	0.93	0.01	3.18	0.24	3.36	0.31	0.66	0.20	3.27	0.30	3.09	0.27	3.29	0.37	3.43	0.34	0.49	0.50

	S-STEM Survey Results for all About You Items																					
	Main Effect of Intervention						Main Effect of Group						Intervention X Group									
Item	Pre Survey Mean	Pre Survey Std. Error	Post Survey Mean	Post Survey Std. Error	Pre vs. Post Sig.	f-value	C1 Mean	C1 Std. Error	C2 Mean	C2 Std. Error	C1 vs. C2 Sig.	f-value	C1 Pre Survey Mean	C1 Pre Survey Std. Error	C1 Post Survey Mean	C1 Post Survey Std. Error	C2 Pre Survey Mean	C2 Pre Survey Std. Error	C2 Post Survey Mean	C2 Post Survey Std. Error	Intervention X Cohort Sig.	f-value
AY1	2.82	0.10	2.91	0.08	0.26	1.38	2.73	0.10	3.00	0.12	0.10	3.03	2.64	0.12	2.82	0.10	3.00	0.15	3.00	0.12	0.26	1.38
AY2	2.88	0.08	2.93	0.06	0.44	0.62	2.96	0.08	2.86	0.10	0.45	0.60	2.91	0.10	3.00	0.07	2.86	0.13	2.86	0.09	0.44	0.62
AY3	2.96	0.06	3.00	0.00	0.44	0.62	2.96	0.04	3.00	0.04	0.44	0.62	2.91	0.07	3.00	0.00	3.00	0.09	3.00	0.00	0.44	0.62
AY4	2.87	0.09	2.96	0.06	0.18	1.94	2.91	0.08	2.92	0.11	0.96	0.00	2.91	0.10	2.91	0.07	2.83	0.14	3.00	0.10	0.18	1.94
AY5	2.87	0.09	2.96	0.06	0.18	1.94	2.91	0.08	2.92	0.11	0.96	0.00	2.91	0.10	2.91	0.07	2.83	0.14	3.00	0.10	0.18	1.94
AY6	2.08	0.23	2.16	0.21	0.67	0.19	1.96	0.25	2.29	0.31	0.41	0.70	1.73	0.28	2.18	0.27	2.43	0.35	2.14	0.33	0.07	3.69
AY7	2.05	0.24	2.26	0.23	0.27	1.31	1.96	0.27	2.36	0.34	0.36	0.88	1.82	0.29	2.09	0.29	2.29	0.37	2.43	0.36	0.73	0.13
AY8	1.98	0.23	2.02	0.23	0.84	0.04	2.00	0.26	2.00	0.33	1.00	0.00	1.82	0.29	2.18	0.29	2.14	0.36	1.86	0.36	0.11	2.89
AY9	1.84	0.23	2.02	0.21	0.44	0.62	2.00	0.24	1.86	0.30	0.71	0.14	1.82	0.29	2.18	0.27	1.86	0.36	1.86	0.33	0.44	0.62