T.I.M.E. FOR STEM: TRANSFORMING INTEGRATIVE MAKERSPACE EDUCATION

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ABSTRACT

The T.I.M.E. for STEM project, supported by the National Science Foundation, represents a collaborative effort between the School of Education (SOE) and the Department of Natural Sciences, Engineering, and Technology (NSET) at Point Park University. This initiative aims to elevate the quality of STEM education for pre-service teachers by integrating interdisciplinary learning within a makerspace environment. Drawing on the National Institute for STEM Education (NISE) guiding principles and domains, NSET faculty provided professional development to SOE faculty on STEM content knowledge, while the T.I.M.E. for STEM community partners contributed additional expertise in makerspace pedagogy. This qualitative study explores the pedagogical growth of pre-service teachers and faculty members in STEM learning and teaching within makerspace settings. Utilizing a content analysis approach, pre andpost surveys were administered to assess participants' understanding of maker pedagogy and STEM learning. The findings reveal significant improvements in participants' perceptions and practices across key domains outlined by NISE, including creating an environment for learning,building scientific understanding, and engaging students in scientific and engineering practices. Moreover, the project's broader impact extends beyond its direct participants, with potential for replication and scalability across institutions. By leveraging community partnerships and adaptable makerspace activities, T.I.M.E. for STEM offers a model for enhancing STEM education that is accessible to diverse educational contexts. This initiative underscores the importance of interdisciplinary approaches and technology integration in preparing educators to foster student success in STEM disciplines, thereby addressing the critical need for effective STEM teachers and promoting positive attitudes towards STEM subjects from an early age.

KEYWORDS

STEM education, Makerspace pedagogy, Pre-service teachers, Interdisciplinary learning, Technologyintegration

1. INTRODUCTION

1.1 Overview:

"Transforming Integrative Makerspace Education for STEM" (National Science Foundation funded project) focused on improving the quality and effectiveness of STEM education for pre-service teachers. The project builds on the knowledge about teaching and learning by creating, implementing, and assessing faculty development, interactive instruction, and STEM lesson plan development. This study fostered a more collaborative approach among education and STEM

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faculty, resulting in the revision and implementation of 10 interdisciplinary education core and methods courses to emphasize STEM experiential learning through makerspace pedagogy. The project addressed the following research question: What do pre-service teachers (education students) and faculty members identify as areas of pedagogical growth in STEM learning and teaching in a makerspace environment?

The School of Education (SOE) and the Department of Natural Sciences, Engineering and Technology (NSET) Faculty from a northeastern university in the United States collaborated on this project. NSET faculty who are content experts in mathematics, biology, and physics provided professional development for SOE faculty on STEM content knowledge using the National Institute for STEM Education (NISE) guiding principles and domains (National Institute for STEM Education, 2020). Using the NISE guiding principles as a framework, professional development activities focused on constructivism, explicit and reflective methodology, and development of STEM skills for a 21st century workforce. Through this approach, professional development activities fostered a common language among NSET and SOE faculty, thereby establishing a more collaborative, constructivist approach for improving STEM teaching and learning. TIME for STEM community partners, a local children's museum and an educational training organization provided additional professional development on makerspace pedagogy to SOE faculty.

1.2 Maker Education for STEM Teaching and Learning.

Traditional STEM education often confines students to subject silos, hindering their ability to apply knowledge authentically. In recent years, maker education has gained traction as a transformative approach to teaching STEM subjects. Maker education offers a transformative alternative, fostering creative, collaborative learning experiences that align with real-world STEM practices. Research has shown that over the 15 years since its inception, Science, Technology, Engineering, and Mathematics (STEM) continue to be taught separately in subject silos in schools (Blackley & Howell, 2015), and there is little or no integration to emulate how professionals in society actually work. The utilization of a Makerspace provides opportunities for students to engage in problem-solving projects, and a deeper understanding of STEM concepts. It has been suggested that makerspaces enhance students' agency and persistence in their engagement in learning, contributing to their STEM learning, and provides them with 21st century skills crucial for working and functioning in contemporary society (Bevan et al., 2016). Our project sought to capitalize on this potential by empowering pre-service teachers to integrate maker educationinto their future classrooms.

Over the past decade, the makerspace education movement has been on the rise, and educators, along with policy makers, have expressed a heightened interest in maker-centered learning, particularly in STEM learning. Makerspace labs or classrooms are the physical collaborative workspaces for making, learning, exploring, and sharing, and they utilize high-tech to no-tech tools. Maker-centered learning has shown an increased proficiency in STEM subjects and extended interest in STEM fields because of makerspace education (Clapp, 2016). Despite the growing implementation of makerspace education, a surprising 40% of teachers recently reported that they were underprepared to effectively teach in a maker environment (Cross, 2018). According to Cross, this lack of preparedness is directly related to the lack of understanding and training in STEM education and maker-centered learning.

To effectively prepare teachers to instruct in a makerspace, educators need strategies to handle the pedagogical and technological infrastructure of makerspaces proficiently. Moreover, such novel learning environments call for the development of increasingly flexible ways of working with students and with teams of teachers. McCubbins (2016) found that students' engagement was linked to their facilitators' knowledge and support. Teachers need opportunities to experience maker education through professional development opportunities (Paganelli, et al., 2017). Further benefits to intentional teaching incorporate an emphasis on learning goals and a promotion of all content areas; highlighting social-emotional development; and an intentional support of communication skills (Leggett and Ford 2013). There is a need for more research on the role of the teacher in supporting students' learning in makerspaces. That is, how to navigate and balance the need for structure and support while maintaining students' agency and sustained interest in making and STEM learning within institutional constraints.

An emerging body of recent research literature has documented the skills and competencies children acquire when they participate in makerspaces. For many, making constitutes ways of reaching educationally progressive goals that are not easily realized in more traditional educational practices valuing students' problem-finding, problem solving and collaboration, and where students can develop their abilities to design and produce artifacts using a variety of materials and resources (Smith & Smith, 2016). Furthermore, makerspaces are regarded as being well suited to diverse learners, accommodating a diversity of interests and levels of engagement (Johnson & Halverson, 2015). Focusing our research on making education is significant, especially during a time when inequalities in STEM career pathways exist (National Science Foundation, 2018), specifically for our preservice teacher candidates who often do not see themselves as valued STEM experts. Smith, Hielscher, Dickel, Soderberg, and Oost (2013) emphasize that Makerspaces are really about the community and connections that develop while the individuals are creating in the space.

Maker education is an important and beneficial approach to teaching that transforms instruction to a student-centered, hands-on focus. Maker education also has precedents in education: project-based learning and Jean Piaget's constructivism, which focus on the accomplishments of young makers in a classroom where knowledge is achieved through experience (Martinez, 2018). At the core of maker education is an iterative process that helps promote empathy and curiosity, especially for young learners. (Bers, Strawhacker, & Vizner, 2018). During the critical development period of ages 8-11, young learners have an opportunity to shift from STEM learning through making to an even greater formation of a "maker mindset." Making offers a gateway to the development of the child's identity as being STEM capable and STEM- interested students to those who can pursue STEM careers. (Chu et al., 2019). Through core educational practices and ideas, maker education empowers young children by fostering thoughtful reflection, exploring complexity, and finding opportunity in maker-centered learning.(Clapp, Ross, Ryan, & Tishman, 2016).

2. THEORETICAL FRAMEWORK

As institutions of higher education focus on high-impact practices for undergraduate students, interdisciplinary STEM learning and teaching in a makerspace environment is an innovative approach to STEM education preparation for pre-service teachers. The T.I.M.E. for STEM project leveraged community partners and makerspace activities that were flexible enough to be replicated at institutions with or without their own makerspace labs. The theoretical framework for effective STEM education can be traced back to Piaget and Vygotsky's theories on constructivist and social constructivist teaching and learning, whereby learning is an active process (Piaget, 1969; Vygotsky, 1978). Experiential learning builds upon Piaget and Vygotsky's theories by engaging students in an activity or experience and then guiding them to reflect upon the respective activity or experience. The positive benefits of experiential learning are well documented (Kuk, 2018; Kolb, 2017; Coker, 2015; Eyler, 2009; Kolb, 1984). Authentic learning experiences have been shown to improve students' academic performance in STEM education (Blue, 2014). They differ from traditional teacher-led and content-focused methods, transforming instruction to engage students in learning new concepts and processes of STEM education.

Authentic instruction includes five components: (1) higher-order thinking, (2) depth of knowledge, (3) connectedness, (4) substantive conversation, and (5) social support for student achievement (Blue, 2014). To support student acquisition of STEM skills and literacy, teachers must provide opportunities for students to learn, reflect upon, and develop the skills for scientific thinking. Classroom teachers can develop STEM thinking by gaining content knowledge in STEM disciplines, participating in authentic learning experiences through an interdisciplinary approach, and experimenting with STEM activities (Blue, 2014). The T.I.M.E. for STEM project builds on a model of improving STEM education through community partnerships and faculty development, but also combines institutional partnership for faculty development and student growth integrating STEM teaching and learning across the curriculum for preK-4 certification students.

3. METHODS

This research project was a mixed-methods study that used a content analysis approach to explore the data. The guiding research question: What do pre-service teachers (education students) and faculty members identify as areas of pedagogical growth in STEM learning and teaching in a makerspace environment? The authors collected data using the following data collection tools: Year 1- Faculty Pre-Survey, Faculty Reflection Statements. These same surveys were used during Year 3 of the project as part of the Post-Survey. The project utilized a content analysis approach (Bazeley, 2013) of the text documents noted above. Data was coded using NVivo data management software to facilitate deeper data analysis within each data source as well as across all data sources. Data was analyzed in the light of the research question and codes were identified using a descriptive coding method. Descriptive coding from various data collections across different time periods are essential for assessing participant growth (Saldana, 2008). The descriptive codes categorized the data by topic and provided an organizational scope of the project. A thematic analysis was used to categorize the descriptive codes, establish relationships, and identify the significance of the relationships as it applies to the research project. The thematic analysis approach provides a rich and detailed account of the data in a qualitative study (Braun & Clark, 2006).

4. RESULTS

This research team analyzed the data from the pre and post surveys. The following indicate the results.

<u>**Student Pre/Post Results:**</u>

Creating an Environment for Learning:

When evaluating the pre and post survey results from this section looking for significant differences between the two surveys, the following were considered:

- Space-centered versus Student-centered
- Specific examples of how makerspace could be applied to real-world problem

<u>Space-Centered versus Student-Centered</u>

Results from the pre-survey indicate that more than one third of participants were unable to define what a makerspace environment entails. One quarter of participants focused on the space and slightly over one third of the participants articulated how students interact with the maker space to promote learning. As shown, there is a significant increase in post-survey results.

Creating an Environment for Learning

Survey	Space Centered	Not Defined	Student Centered
Pre-Survey	25%	37%	38%
Post-Survey	10%	0%	90%

Creating an Environment for Learning			
Survey	Space Centered	Not Defined	Student Centered
Pre-Survey EDUC 100+	23%	60%	17%
Pre-Survey EDUC 300+	31%	0%	69%
Post-Survey	10%	0%	90%

Qualitative evidence from the data include comments such as:

Space Centered:
- “A makerspace is an open and inviting environment, filled with lots of hands-on materials, activities, technology, and things that makes students, teachers, and others want to be in the makerspace.”
- “Open room with space and tools to learn.”

Not Defined:
- “I do not know.”
- “I have never used this.”

Student Centered:
- “A maker space looks like a resource-rich environment that allows students to be hands- on and open ended. Students interact within a maker space by asking questions, using peer opinions, and collaboration to create and explore.”
- “A makerspace looks like a space where students can solve a problem using hands on materials, creating things and students interact in the makerspace by being in small groups and working together to build the designed activity or solving the problem to the question.”

Results from the post-survey indicate that all participants were able to define what a makerspace entails. Furthermore, a vast majority of the participants clearly articulated how students interact with the makerspace to promote STEM learning. Evidence fromthe data include comments such as:

Space Centered:
- “A space that has tools, machines, craft supplies of all sorts and recycled products. Students can create items integrated thru lessons.”

Student Centered:
- “It looks like creative lesson waiting to happen! Students absolutely love makerspace,and they are extremely engaged in the whole process.”
- “A makerspace is a loosely structured space made to support creativity and engage science, technology, engineering, art and math. In a makerspace there is an array of tools materials that students can utilize to create ideas and prototypes. “

<u>Connecting the Makerspace to Real-World Problems:</u>

Connecting Makerspace Activity to Real-World Problem		
Surveys	Connections to Real-World Problem	Did Not Make Connections to Real-World Problem
Pre-Survey	26%	74%
Post-Survey	100%	0%

Connecting Makerspace Activity to Real-World Problem		
Surveys	Connections to Real-World Problem	Did Not Make Connections to Real-World Problem
Pre-Survey EDUC 100+	13%	87%
Pre-Survey EDUC 300+	48%	52%
Post-Survey	100%	0%

Results from the pre-survey indicate only one quarter of participants were able to connect a makerspace activity to a real-world issue. Qualitative evidence from the data include comments such as:

Connections to Real-World Problem:

- "Makerspace activities provide students with real-world experiences. While in the space, students have the opportunity to build, design, create, and ultimately take control of their own education. By working with maker space, students are given the opportunity to engage in ways that are seen more often in the real workplace by being collaborative andcreative."
- "Makerspace encouraged problem solving skills using limited resources which can be a real world life skill that could be very useful across many different settings."

Did Not Make Connections to Real-World Problem:

- "Having guest speakers and/or field trips could connect what the students are learning inside the makers-apace to the real-world."
- "I'm not sure."

Results from the post-survey indicate that all participants are able connect a makerspace activity to a real-world issue. Qualitative evidence from the data include comments such as:

Made Connection to Real-World Problem:

- "The best way is to connect to real world issues. Through using a concept like a human-centered design activity, students can pick a cause that is meaningful to them, or one could be provided, and they have to work together to find a solution for it."
- "Using recyclable materials and real-world problem-solving activities is a great way toconnect education to real life scenarios. Say one activity could be about pollution, get students thinking about the ways they could reduce pollution and have them build a prototype."

Did Not Make Connections to Real-World Problem:N/A

Building Scientific Understanding: The research team investigated if teaching in a makerspace had an impact on STEM teaching and learning in regard to building scientific understanding. The following data was revealed.

Type of Activities Utilized Prior To and Following STEM instruction				
Surveys	Teacher Directed/Structured	Not Defined	tudent Centered w/o proposed activities	tudent Centered w/ proposed activities
Pre-Survey	6%	66%	23%	5%
Post-Survey	18%	27%	27%	27%

Type of Activities Utilized Prior To and Following STEM instruction				
Surveys	Teacher Directed/Structured	Not Defined	tudent Centered w/o proposed activities	ntered w/ proposedactivities
Pre-Survey EDUC 100+	5%	75%	18%	2%
Pre-Survey EDUC 300+	8%	44%	41%	7%
Post-Survey	18%	27%	27%	27%

Results from the pre-survey indicated that two-thirds of the participants were unable to identify activities that promote student investigation and inquiry prior to and following formal STEM instruction. Furthermore, of those that identified types of activities, only 15% proposed a specific student-centered STEM activity utilized in conjunction with a makerspace. Qualitative evidence from the data include comments such as:

Teacher Directed:

- "One way to encourage students to identify misconceptions is by asking questions yourself. Students will follow your lead as you begin to question why things are a certainway."

Not Defined:

- "I am looking forward to learning about this more while taking more science-basedcourses."
- "Student investigation, inquiry, exploration, and problem solving) can help shape skills important to those in STEM."

Student-Centered without proposed activities:

- "Inquiry and problem solving can be integrated as a part of the everyday classroom. Encouraging students to explore the world around them and ask questions can introduce them to STEM thinking before it is formally introduced."

- "Student inquiry and problem solving (in the makerspace) can be utilizing prior to STEM instruction in the general classroom setting. By providing students with unique assignments and more open-ended projects, this gives them the opportunity to explore their interests and become more well-rounded in their education."

Student-Centered with proposed activities:

- "In a science class, …students… might… build a contraption that would allow an egg not to break. (Students) could form hypothesis, like a good drop device would need a lot of cushion…. The students could then spend a day… learning about force and then spend time in a makerspace developing a device…. To test if it works, students could drop the egg from a high place This would allow them to try different things to find a solution."

Results from the post-survey indicate that participants who previously were unable to define or identify activities to promote student investigation and inquiry prior to and following formal STEM instruction were better able to do so. Such activities focused on student-centered or open-ended versus teacher-centered or structured by a three-to-one ratio. Evidence from the data include comments such as:

Teacher Directed:

- "Before taking the students to the makerspace we need to make sure we are teaching them the basics of a STEM lesson and introducing the topic in a developmentally appropriate manner. I also feel asking students what they previously know about STEM and seeing what activities can build from it."

Not Defined:
Unanswered.

Student-Centered without proposed activities:

- "Inquiry-based learning is an essential part of education and can be utilized in STEM instruction by giving students a real-world scenario/problem and giving them access to tools to solve it."

- "Getting the students excited about materials and setting up the environment in a way that promotes that inquiry. Also, through asking prompting and guiding questions throughout the making and the lesson so that the students are constantly reinforcing those problem solving skills."

Student-Centered with proposed activities:

- "These can be utilized prior to and following STEM instruction by first having students research a problem or a topic, then having them think about how they can help resolve it, then having them create the thing that will help the problem, and lastly think about how they can improve what they have made."

- "…researching a problem, exploring ways to help solve that problem, making something to make the problem better, and then, finally, using the finished product to test it out while trying to improve the issues."

<u>Quantitative Result:</u> The participants were asked the following question:

How comfortable are you in your STEM knowledge to ask questions at various levels of cognition, extend ideas, continue inquiry, and further depth of student questions?

1=Not at all 2=Slightly comfortable 3=Moderately comfortable 4=Very comfortable 5=Extremely comfortable

Data from the pre-survey and post-survey were compared using a Welch's t-test to investigate if there were any differences in the participants comfort level with STEM knowledge as it relates to asking questions, extending idea, continuing inquiry, and furthering depth of student questions.

Group Statistics

	GroupQ7	N	Mean	Std. Deviation	Std. Error Mean
StudentQ7	Pre	66	2.83	1.001	.123
	Post	10	4.00	1.054	.333

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
StudentQ7	Equal variances assumed	.056	.814	-3.411	74	.001	-1.167	.342	-1.848	-.485
	Equal variances not assumed			-3.283	11.599	.007	-1.167	.355	-1.944	-.389

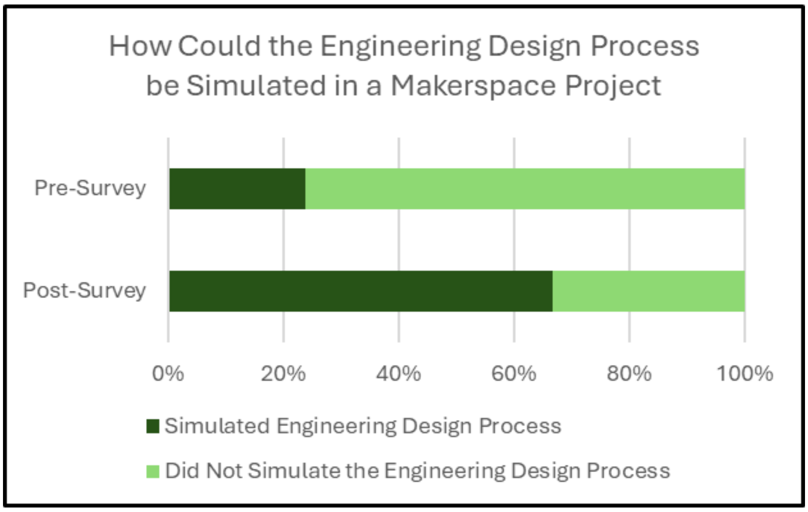
Test results (p-value = .007 < .05) indicate a significant difference between pre- and post-survey comfort level. Cohen's d indicates the effect size would be considered "large" for this difference. Participants had a higher comfort level with STEM knowledge as it relates to asking questions, extending idea, continuing inquiry, and furthering depth of student questions in thepost-survey.

Independent Samples Effect Sizes

		Standardizer[a]	Point Estimate	95% Confidence Interval Lower	95% Confidence Interval Upper
StudentQ7	Cohen's d	1.008	-1.158	-1.845	-.463
	Hedges' correction	1.018	-1.146	-1.826	-.459
	Glass's delta	1.054	-1.107	-1.922	-.254

Engaging Students in Scientific and Engineering Practices:

Qualitative Result #1:



Pre-survey results indicated that seventy-six percent (76%) of participants were unsure of howthe Engineering Design Process could be utilized to simulate a makerspace project:

Qualitative evidence responses included:

"Having a comfortable space/ environment for students to work and having the rightmaterials."

"Using all sensory forms to express emotion within the objects and supplies provided in the makerspace"

"I'm not sure."

"Not sure of the engineering design process."

"Write down notes online, have online instructional video, compare students results to photos online.”

Post-survey results indicated that sixty-six (66%) of participants had an emerging or developed idea of how the Engineering Design Process could be utilized to simulate a makerspace project:

Qualitative evidence responses included:

“Define the problem and come up with a solution by designing a prototype and testing and retesting it while running it by peers.”

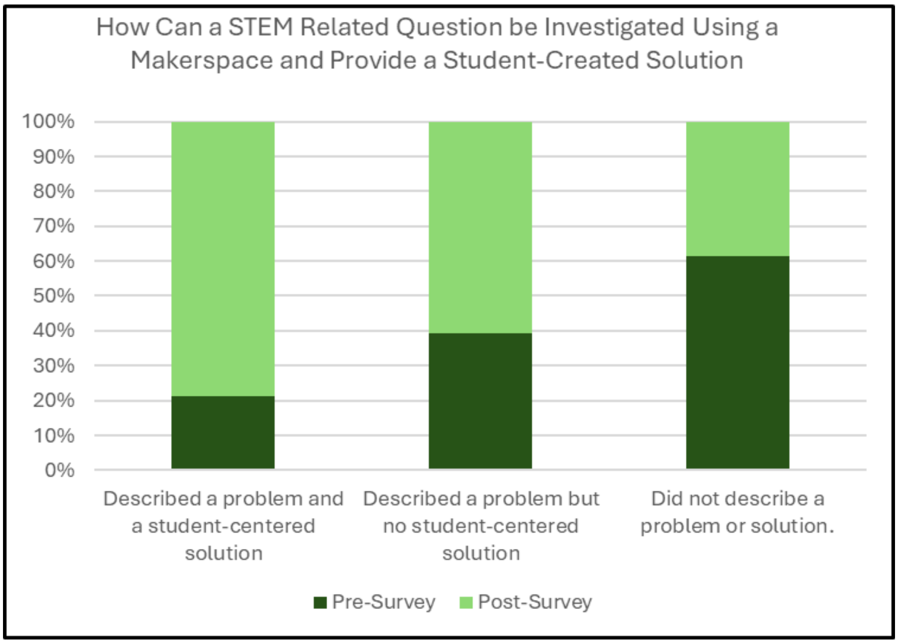
“The engineering design process is thinking about a problem, coming up with solutions for it, thinking about what materials you need to create your solution, making your idea, and reflecting upon what you could do to improve it. This could be simulated in a makerspace project by having students fill out a design planning sheet and then creating using the materials present.”

“The engineering design process is a series of steps that engineers follow to come up with a solution to a problem. It can be simulated in the prototype phase of the design process.”

Qualitative Result #2:

Describe how a STEM related question could be investigated using a makerspace and provide an example of a student-created solution utilizing materials in the makerspace?

Participants Response			
	Described a problem and a student-centered solution	**Described a problem but no student-centered solution**	**Did not describe a problem or solution.**
Pre-Survey	8%	13%	79%
Post-Survey	30%	20%	50%



Post-survey showed the least amount of growth in this area. One-half of the post-survey students were unable to describe a problem that could be investigated using a makerspace. Responses such as the following showed a general understanding of how a question could beinvestigated but not specific example could be sited:

"A stem related question can be investigated by students with a stem
room by allowing them to express that question in whatever creative way they want."

"Using a makerspace can allow students the creativity and the materials to find a solution to a STEM related question."

Responses that did describe a problem and solution included:

"I have a plant that does not seem to grow anymore. If we make my plant out of makerspace materials can you show me how we can get the plant to its fullest potential? They could make a watering system, bring in the sun, change the soil all out of makerspace materials."

"A STEM question that I used with students that participated in a STEAM Day was 'How are we able to reduce the amount of air pollution in our environment?' Students then wereable to come up with their own ideas and solutions during a discussion, then were able to create what I had come up with which is a wind powered vehicle. Students created their own wind powered vehicles using materials such as toilet paper rolls, paper, glue, popsiclesticks, etc. and attempted to make their vehicle move using a hair dryer."

Quantitative Result #1: Participants were asked the following question:

How comfortable are you with your STEM knowledge to use guiding questions to facilitate student learning in a makerspace environment?

1=Not at all 2=Slightly comfortable 3=Moderately comfortable 4=Very comfortable 5=Extremely comfortable

Data from the pre-survey and post-survey were compared using a Welch's t-test to investigate if there were any differences in the participants comfort level with STEM knowledge as it relates to guiding questions to facilitate student learning.

Group Statistics

	GroupQ14	N	Mean	Std. Deviation	Std. Error Mean
StudentQ14	Pre	65	2.69	1.158	.144
	Post	10	4.00	.667	.211

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
StudentQ14	Equal variances assumed	6.193	.015	-3.470	73	<.001	-1.308	.377	-2.059	-.557
	Equal variances not assumed			-5.126	18.730	<.001	-1.308	.255	-1.842	-.773

Independent Samples Effect Sizes

		Standardizer[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
StudentQ14	Cohen's d	1.109	-1.179	-1.868	-.482
	Hedges' correction	1.121	-1.167	-1.848	-.477
	Glass's delta	.667	-1.962	-3.056	-.831

Test results (p-value < .001 < .05) indicate a significant difference between pre-survey comfort level and post-survey comfort level. Cohen's d indicates the effect size would be considered "large" for this difference. Participants had a higher comfort level with STEM knowledge as it relates to guiding questions to facilitate student learning in the post-survey.

<u>Quantitative Result #2:</u> Participants were asked the following question:

How comfortable are you with your STEM knowledge to assess and critique student scientific design and creation in a makerspace environment?

1=Not at all 2=Slightly comfortable 3=Moderately comfortable 4=Very comfortable 5=Extremely comfortable

Data from the pre-survey and post-survey were compared using a Welch's t-test to investigate if there were any differences in the participants comfort level with STEM knowledge as it relates to assessing and critiquing student design and creations.

Group Statistics

	GroupQ15	N	Mean	Std. Deviation	Std. Error Mean
StudentQ15	Pre	65	2.69	1.145	.142
	Post	10	4.20	.632	.200

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
StudentQ15	Equal variances assumed	4.718	.033	-4.055	73	<.001	-1.508	.372	-2.249	-.767
	Equal variances not assumed			-6.147	19.653	<.001	-1.508	.245	-2.020	-.995

Independent Samples Effect Sizes

		Standardizer[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
StudentQ15	Cohen's d	1.094	-1.378	-2.075	-.671
	Hedges' correction	1.106	-1.363	-2.054	-.664
	Glass's delta	.632	-2.384	-3.638	-1.096

Test results (p-value < .001 < .05) indicate a significant difference between pre-survey comfort level and post-survey comfort level. Cohen's d indicates the effect size would be considered "large" for this difference. Participants had a higher comfort level with STEM knowledge as it relates to assessing and critiquing student design and creations in the post-survey.

5. CONCLUSION

The National Science Foundation funded project, T.I.M.E. for STEM, findings reveal significant improvements in participants' perceptions and practices across key STEM domains outlined by NISE, including creating an environment for learning, building scientific understanding, and engaging students in scientific and engineering practices. Moreover, the project's broader impact extends beyond its direct participants, with potential for replication and scalability across higher education institutions. By leveraging community partnerships and adaptable makerspace activities, T.I.M.E. for STEM offers a model for enhancing STEM teaching and learning that is accessible to diverse educational contexts. This initiative highlights the importance of interdisciplinary approaches and technology integration in preparing educators to foster student success in STEM disciplines, thereby addressing the critical need for effective STEM teachers and promoting positive attitudes towards STEM subjects from an earlyage.

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