Technology Leaders Initiative: Developing Tomorrow's Science, Technology, Engineering, and Mathematics (STEM) Achievers

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Abstract

The Yaeger Foundation, Inc. and the St. Thomas University Institute for Education formed a partnership to promote science, technology, engineering, and mathematics (STEM) education. Ivan Yaeger founder of Yaeger Foundation and the inventor of the Robotic Bionic Arm Prototype received a patent from the United States Patent and Trademark Office in 1988. This initiative gave 20 preprofessional students the opportunity to complete a 10-week field experience at an urban school by implementing the Foundation's Technology Leaders Initiative (TLI). These students implemented the TLI curriculum at select Miami-Dade County Public Schools in South Florida. TLI allows students who have never encountered higher-order thinking of mathematics and science methods courses to identify and to implement effective hands-on approaches to improving STEM teaching and learning before becoming professional teachers. Results showed that preservice students completed the methods course successfully, showed tremendous progress in STEM, and produced electrical circuits and mechanical system prototypes.

Keywords: field experience, preservice teacher, Technology, partnership, STEM, student internship, and urban schools

Introduction

The Yaeger Foundation, Inc. and the St. Thomas University (STU) Institute for Education formed a partnership to promote science, technology, engineering, and mathematics (STEM) education in the classroom. Ivan Yaeger (Mr. Yaeger), the founder of Yaeger Foundation and the inventor of the Robotic Bionic Arm Prototype, received a patent from the United States Patent and Trademark Office in 1988. This initiative gave preprofessional students the opportunity to complete a 10-week field experience as a facilitator at an urban school by implementing the foundation's Technology Leaders Initiative (TLI).

TLI is a STEM-based Kindergarten through Grade 12 workshop curriculum created by Mr. Yaeger. TLI uses invention and entrepreneurship to teach real-world applications of key skills and to boost student achievement. A total of 20 university students majoring in the Elementary Education and Secondary Education Programs completed the field experience by serving as TLI facilitators. These students implemented the TLI curriculum at select Miami-Dade County Public Schools in South Florida for elementary and middle-school classes. TLI allows students in mathematics and science methods courses to identify and to implement effective approaches to improving STEM teaching and learning before becoming professional teachers. Students at various urban or inner schools who had never been exposed to science and mathematics higher-order thinking work were given the opportunity to complete this hands-on STEM program during TLI curriculum. This researcher and Mr. Yeager conceived the framework of this study as a means of facilitating a science education program that promoted higher-order thinking. The results showed that preservice students completed the methods course successfully, students at the urban schools showed tremendous progress in STEM, and produced prototypes that consisted of electrical circuits and mechanical systems.

Problem Statement and Purpose

According to the U.S. Department of Education (2010), the United States has become a global leader, in large part, through the genius and hard work of its scientists, engineers, and innovators.

Yet, currently, comparatively few students in the United States pursuing expertise in the STEM fields and by an inadequate pipeline of teachers skilled in those subjects threaten that position. The problem is that many teachers come into the classroom lacking the passion, methodology, and knowledge to teach science, technology, or mathematics; therefore, this initiative gives preprofessional teachers the opportunity to teach in a STEM program. These students are majoring in Elementary Education and Secondary Education at the university. They complete a 10-week field experience as facilitators at an elementary or middle school in Miami-Dade County Public Schools in South Florida implementing STEM into the curriculum.

Many students in inner-city schools do not have exposure to extensive science and mathematics hands-on experiences and investigation. Students are not thinking critically in the subjects of science and mathematics. The achievement gap between low-income and high-income students worsens as technology becomes more integral to 21st century professions and as urban U.S. schools struggle to prepare students for this new job market. A Title I STEM magnet public school in Washington, D.C., has implemented a similar program to TLI in order to change the achievement gap and encourage students' interest in STEM. According to Huang (2013), low-income African American students, similar to Whites, usually do not have the opportunities to participate in STEM classes. Pursuant to the U.S. Department of Education, only 29% of high schools with large minority student populations offer calculus compared with 55% of schools with small minority populations (Huang, 2013). STEM education also pays off in the future. Therefore, the researcher believes that students should be exposed to STEM in elementary school. TLI targets students not just in high school but begins working with students in elementary school.

Tytler (2010) indicated that with primary science teaching and learning and the professional development of teachers, evidence has shown hands-on experimentation and higher-order thinking will help to improve science engagement and learning in science in primary school classrooms. The major factors identified in Tytler's (2010) review that frame children's response to science and mathematics are early life experiences, gender, and pedagogy, which have a critical impact on interests in the subject. In addition, the review found considerable evidence that, for the majority of students, their life aspirations form before the age of 14.

The purpose of this article is to present the experience of a preprofessional during a 10-week field experience with the integration of the STEM program. The present initiative provided students in urban schools an opportunity to create, investigate, and evaluate in the subjects of science and mathematics. This allows students to do work at higher-order thinking of Bloom's taxonomy, such as applying, analyzing, evaluating, and creating. The cognitive process dimension represents a continuum of increasing complexity from remembering to creating, which is a revision of the framework of Bloom's taxonomy (Krathwohl, 2002).

TLI uses invention as a vehicle to motivate and to teach students. TLI consists of a series of hands-on invention and business development workshops in the Kindergarten through Grade 12 sector. This program allows students in both mathematics and science methods courses to experience teaching while identifying and implementing effective approaches in improving STEM teaching before becoming professional teachers. Students follow a scripted lesson implementing the Florida Department of Education (2014) Next Generation Sunshine State Standards for Science and later implemented the Florida Standards (2014) CPALMS Educator Toolkits. The CPALMS Educator Toolkits is a toolbox of information, vetted resources, and interactive tools that help educators effectively implement teaching standards (Florida Standards, 2014).

The preprofessional teachers facilitated students in forming teams with the assistance of the cooperating teacher (the veteran teacher the university student works with in the classroom). On the 1st day of the workshop, the students in both District 1 and District 2 took a pretest that consisted of science, mathematics, and business questions encompassing multiple choice, fill in the blank, and short responses. Then the students created a startup team. Each team operated as a simulated product development startup company. The preprofessional teacher guided these teams through the engineering of their new products. The activity helped to develop skills, such as team-building, critical thinking, creativity, and scientific exploration. The participants were able to discover practical applications of mathematics and scientific concepts. They also learned the process of building prototypes and applying for patents, trademarks, and copyrights. The teams completed the 10-session program by delivering a corporate-style presentation showcasing their work (see Figures 1, 2, 3, 4). After each student's presentation, while they took their posttest, the teachers completed a host-teacher survey (see Table 1 and Table 2 below).

The partnership yielded another STEM-related professional development opportunity. Members of St. Thomas University's Future Teachers of America (FTA) participated as volunteers at the foundation's Bionic/Robotic Hand Competitions. Middle and senior high school teams in both Miami-Dade County's and Broward County's SECME-STEM Olympiads competed by reengineering electronic prosthetic hands assembled from foundation-supplied Bionic/Robotics Hand Kits. Volunteers assisted the Competition Committee while teams demonstrated their hand prototypes to a panel of judges for final evaluation (see Figures 3, 4, and 5). According to Wilkerson and Haden (2014), Out of School Time (OST) Programs operate under funding constraints, with tight budgets and ever-increasing calls for accountability. In the past, teachers often did not read or use the results of evaluations commissioned to satisfy the accountability requirements of funding agencies or supervisory organizations. STEM OST programs that engage students for longer periods of time, such as afterschool, Saturdays, or summer programs, hold greater potential for affecting intermediate and long-term outcomes than do short-duration programs

Definitions of Terms

This article uses the following terminology and definitions:

Field experience. The experience is a key component of many teacher preparation programs. According to recent education reforms in many countries, several universities have been reexamining, refining, and implementing teacher education programs that are aligned with curricular, pedagogical, and organizational reforms. These teacher education institutions have an increased focus on the development of field experience courses (Russell, 2005). Since field experience is considered as a bridge between the academic coursework and the realities of classroom teaching, preservice teachers can learn how to teach a particular content topic to specific students in a specific context (Beeth & Adadan, 2006; Kagan, 1992 as cited in Faikhamta, Jantarakantee, & Roadrangka, 2011).

Preservice teachers. Preservice teaching is a period of guided, supervised teaching. A mentor or cooperating teacher gradually introduces the college student into the teaching role for a particular class. Preservice teachers also have the opportunity to work with students, which serves as a preparatory activity before they assume the full responsibilities of a teacher. In a real-school atmosphere, preservice teachers can begin to negotiate classroom management, school policies, organization, lesson planning, and their own positions within the social structure of the school (Russell, 2005).

STEM. Science, technology, engineering, and mathematics programs in out-of-school time (OST) supplement schoolwork, ignite student interest, and extend STEM learning. From interactive museum exhibits to summer long science camps, opportunities for informal student engagement in STEM learning abound (Wilkerson & Haden, 2014).

Literature Review

This section of the article consists of various research studies on technology in the 21st century, science in urban schools, and field experiences and student internships at teachers' programs.

Technology in the 21st Century

Teaching students through the use of technology prepares them to be citizens in the 21st century as the use of technology affords students to obtain information from resources all over the world. Technology allows students to encounter global occurrences and trends that are continually changing. Technology has been influential in reframing mannerisms, social interactions, individual thought processes**,** and ways of living. Students are able to continually learn about change, which is conducive to adaptation (Abruscato & DeRosa, 2009).

According to the National Center for Education Statistics (NCES, 2012), the Institute of Education Sciences (IES) connects research, policy, and data in the nation relative to conducting and providing science research. Although the state has no authority over the district, there are requirements and standards set in which the local school district must be in compliance. Standardized testing is the most primitive compliance factor. The IES provides statistical data that validate the decline in proficiency in science for U.S. students. The effects of the funding support and hours educators, facilitators, and administrators in schools are putting into the validation of standardized testing cannot be good. The science programs on all grade levels suffer.

Science in Urban Schools

Lee and Maerten-Rivera (2009) conducted a descriptive study on urban elementary school teachers' perceptions of their science content knowledge, science teaching practices, and support for language development of English language learners. In addition, the researchers examined teachers' perceptions of organizational supports and barriers associated with teaching science to non-mainstream students. The teachers reported that they were generally knowledgeable about science topics at their grade level and that they taught science to promote students' understanding and inquiry. In contrast, the teachers reported rarely discussing student diversity in their own teaching or with other teachers at their schools. The teachers identified specific organizational supports and barriers in teaching science with diverse student groups at both the school and the classroom levels. In other research conducted by Buxton, Lee, and Santau (2008), they described hands-on intervention curriculum that is beneficial in promoting science.

U.S. Department of Education (2010) research shows students doing hands-on projects in class score higher in standardized tests more frequently. The eighth-grade teacher questionnaire asked teachers how frequently their science students did hands-on activities or investigations in science. Teachers selected one of four responses: "Never or hardly ever," "once or twice a month," "once or twice a week," or "every day or almost every day." In 2011, students whose teachers reported that their students do hands-on projects every day or almost every day scored higher on average than students whose teachers reported students did hands-on projects in class less frequently (see Figures 6, 7, 8, and 9). Fifty-six percent of students in 2011 had teachers who reported students did hands-on projects once or twice a week (NCES, 2012).

Over the past decade, the high-stakes testing regime has squeezed out much of the curriculum that can make schools an engaging and enriching experience for students, and the whole educational system has forced teachers to dilute their creativity to teach to the test. "I would much rather help students learn how to conduct research and how to discuss and how to explore controversies and how to complete multi-task projects than teach them how to recall this or that fact for an exam," explained teacher Connie Fawcett (as cited in Walker, 2014, n.p). "U.S. Education Secretary Arne Duncan recently conceded that too much standardized testing was "sucking the oxygen out of the room" and causing "undue stress" (U.S. Department of Education, 2010, n.p.).

Field Experiences and Student Internships

Field experiences are foundational in preprofessional teacher education programs (Hixon & So, 2009). Therefore, change is inevitable. The wave of the future is digital instruction through the use of technology. Hixon and So (2009) believed teachers and researchers identify technology use in field experiences primarily due to exposure to various teaching and learning environments and to the creation of shared experiences, preparing students cognitively, and learning about technology integration. Preprofessional teacher interaction with professionals in a variety of school and community sites and agencies, further development of content, professional and pedagogical knowledge, skills, and dispositions enhance implementing technology in the classroom. According to Reys, Lindquist, Lambdin, Smith, and Suydam (2009), the National Council of Teachers of Mathematics (NCTM) Technology Principle and Curriculum Principle emphasize the influence of technology and the importance of a flexible approach to curriculum. This partnership presents a creative solution to the challenge of implementing applied STEM experiences for students and educators.

In teacher education, as in many fields, there are several truths, each based on different assumptions and beliefs. Russell (2005) stated that "conventional teacher education reflects a view of learning to teach as a two-step process of knowledge acquisition and application or transfer" (n.p). In this view of truth, the university provides theory, skills, and knowledge through coursework, and the school provides the field setting where preprofessional teachers apply knowledge. The preservice teacher integrates it all. Student teaching is the bridge among theory, knowledge, and skills they gain at the university and apply in their internship school. In a review of 97 empirical studies focusing on learning to teach (Russell, 2005), most of the beginning teachers studied were in programs based on the conventional truth model. However, the notion that coursework should provide teaching skills and information about teaching and that beginning teachers can integrate and effectively implement that information receives very little support from the research.

Field experience is a key component of many teacher preparation programs. According to recent education reforms in many countries, several universities have been reexamining, refining, and implementing teacher education programs that align with curricular, pedagogical, and organizational reforms. These teacher education institutions have an increased focus on the development of field experience courses (Russell, 2005).

Framework

The framework of this study was Bloom's taxonomy (Krathwol, 2002). Therefore, the taxonomy of educational objectives is a framework for classifying statements of what we expect or intend students to learn as a result of instruction. This researcher and Mr. Yeager conceived the framework as a means of facilitating a science education program that promoted higher-order thinking. Furthermore, the initiative used the framework to make sure students implemented hands-on experience, which aligned with constructivism. Constructivism provides a useful theoretical framework in science teacher education for the understanding and development of the learning of science by preservice science teachers. Many researchers regard constructivism as a driving force for science educators to move their attention from teachers' teaching behaviors to teachers' knowledge and how they learn, think, and construct their knowledge. (Their vision of the original taxonomy is a two-dimensional framework: knowledge and cognitive processes.) The former most resembles the subcategories of the original knowledge category. The latter resembles the six categories of the original taxonomy with the knowledge category named remember, the comprehension category named understands, the synthesis category renamed create and made the top category, and the remaining categories changed to their verb forms: apply, analyze, and evaluate. Krathwhol (2002) arranged the categories in a hierarchical structure, but not as rigidly as in the original taxonomy. Therefore, both the students at the urban school and the preprofessional students worked on making sure that the students were able to apply, analyze, and evaluate their work. The preprofessionals facilitated and made sure students were able to create an invention through the use of the taxonomy framework and critical thinking.

Results

After the 10 weeks, only 18 students completed the field experience successfully. One student was unable to go to any of the schools due to transportation problems, and another student went to a Catholic school. One of the students observed a third-grade class during math and science classes. She also prepared hands-on discovery type of mathematics and science lesson plans to teach students. Students had to turn in a final paper regarding the TLI experience. Preprofessional students completed their field service by submitting a final paper that consisted of (a) an anecdote, (b) a timesheet a professional teacher and Mr. Yeager signed, (c) a summary about the field experience, (d) information about TLI, and (e) research about STEM education, field experience, and about partnership. The students included this field experience paper in their final portfolio, a requirement for graduation. This collaboration with the TLI program helped to enhance the undergraduate teacher education program at St. Thomas University by allowing pre-professionals to experience prioritizing, promoting, and implementing STEM in the classroom through field experience. Students successfully completed the course and followed the rubric the professor provided with an "A" or "B" (see Appendix A).[1]

In addition, the students in Miami-Dade County Public Schools took a pretest and a posttest. According to the Yaeger Foundation (2014), students at all 20 participating schools in Miami-Dade County Public Schools successfully produced impressive products and presentations. Students also showed significant increases in pretest versus posttest performance. The integration of academic skills into TLI activities creates a powerful learning experience because students (a) discover tangible "real-world" applications of core subjects, (b) discover the correlation between education and earning a living, and (c) learning while engaged in a fun activity. TLI students invented and built 89 products. Every team successfully worked as startup companies and completed all assignments. The majority of prototypes had at least one functioning electrical or mechanical feature (Yaeger Foundation, 2014) (see Figures 5, 6, 7, 8).

Table 1 shows results of the host-teachers survey results and the average of the students' pretest and posttest.

Conclusion

The Technology Leaders Initiative, St. Thomas University, and a local public school system collaborated to enhance student learning in a STEM program. The preprofessional teachers in the teacher education program completed a final paper about their experience teaching and facilitating students at two districts in an urban neighborhood. Out of the 20 preprofessional teachers who completed the field experience, 18 students successfully completed the STEM field experience earning an average of 17% on the assignment, that is, a B+ and above. Preprofessional teachers were able to network with teachers and school principals at the local school, and the school principal hired two of the preprofessional teachers as science and mathematics interventionists and one as a classroom teacher after graduation.

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[1] The students' final papers are on file with this researcher.

Mr. Yaeger hired one student during the Summer TLI program part-time. This partnership benefited all parties involved in areas of academic growth, professional development, and real-life hands-on experience.

Students at the local urban schools were able to work to explore career-related applications of science, mathematics, and other core subjects via the experience of creating their own inventions (Yaeger, 2014). Students at the urban schools showed significant academic progress in STEM and produced prototypes that consisted of electrical circuits and mechanical systems. Overall, the partnership was a success, and we are now in year 2 of this impressive initiative. The goal is to target student teachers to teach in a STEM program. Sawchuk (2014) indicated that the U.S. Department of Education wants its upcoming $35 million investment in teacher preparation to focus on producing effective teachers in the STEM fields of science, technology, engineering, and mathematics, and preparing teachers to instruct to the Common Core State Standards. The preprofessional teachers created lesson plans with strategies to teach students who are English language learners and at risk. The lesson plans aligned with the Common Core State Standards when they completed the assignment and participated in a STEM program that was successful.

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Table 1: Host-Teacher Survey Results

Closing survey statement	Yes	Somewhat	No
Students discovered new forms of computer-based research.	83%	17%	0%
Students learned more about how products and businesses are created	100%	0%	0%
Students learned to solve problems in new ways.	100%	0%	0%
Students developed their ability to communicate ideas.	100%	0%	0%
Students developed their ability to work as a team.	100%	0%	0%
Students developed applied science/tech/engineering/math skills.	100%	0%	0%

Table 2 shows the results of the 20 urban schools that participated in the TLI.

Table 2: TLI Test Results of Student Scores

District 1 schools	Pretest class average	Posttest class average
Urban School 1	29%	65%
Urban School 2	39%	58%
Urban School 3	30%	87%
Urban School 4	48%	83%
Urban School 5	47%	90%
Urban School 6	22.5	59%
Urban School 7	62%	89%
Urban School 8	41%	89%
Urban School 9	64%	95%
Urban School 10	49%	89%
District 2 schools	Pretest class average	Posttest class average
Urban School 1	46%	87%
Urban School 2	41%	78%
Urban School 3	41%	86%
Urban School 4	49%	79%
Urban School 5	56%	87%
Urban School 6	49%	91%
Urban School 7	31%	74%
Urban School 8	53%	75%
Urban School 9	48%	70%
Urban School 10	50%	97%

From "Technology Leaders Initiative," by Yaeger Foundation, Inc., 2014. Retrieved from http://www.fliprogram.com/

Figure 1. Dr. Katsia M. Cadeau & Mr. Ivan G. Yaeger—Partnership Award (March 2014)

Figure 2. St. Thomas University Open House - Award Show (March 2014).

Left to Right: Dr. Katsia Cadeau, Alison Brown, Leocelli Sevilla, Sister Marie France Syldor, Shalamiyah Brown, Jordan Whittingham, Christine Rivera, Jaspreet Thiara, and Mr. Ivan Yaeger.

Figure 3. Students at the Miami-Dade SECME Olympiad.

Figure 4. Students at the Miami-Dade SECME Olympiad.

The School of Technology & Science - Dr. David Quesada and Dr. John Abdirkin and the School of Arts & Education collaborate to volunteer at the Hand Competition. Lead Professor - Dr. Katsia M. Cadeau (green suit). Judge: Gail Alexander. Host: Mr. Ivan Yaeger.

Figure 5. Hand Competition Winner.

Figure 6. "Hando Commando": wireless control bracelet for home electronics

Figure 7. "Blender Cup": self-mixing drinking cup

Figure 8. "Cupbrella": umbrella with holder for a cup or small items

Figure 9. Applied STEM: Students engineer and construct electrical circuits and mechanical systems, perform quality tests, and correct errors.

Appendix A

Technology Leaders Initiative (TLI)

A STEM Field Experience
Course: EDU 303- **Mathematics Instruction in the Elementary Multicultural School Setting.**

Student Name: _____Date: _____
Instructor: Dr. Katsia Cadeau
Owner/Inventor: Mr. Ivan Yaeger
Description: The final assignment is a STEM Field Experience at an assigned school. This assignment is also to form a partnership with Technology Leaders Initiative (TLI), a not-for profit organization. Students are required to facilitate a workshop at an assigned school once a week for 1 hour. As facilitators, you will conduct live workshop sessions, including students who will form simulated product development startup companies. These teams are then guided through the creation and production of their inventions. This activity develops skills such as team-building, critical thinking, creativity, and scientific exploration. Students will discover practical applications of mathematic and scientific concepts. They will also learn the process of building prototypes and applying for patents, trademarks, and copyrights. *Your final paper should be composed of anecdotal/timesheet records, a summary of your field experience, information about TLI, and five cited empirical research studies about partnership between school of education with not-for-profit organization, STEM, and the benefits of field/clinical experience in an education BA program. Finally, a letter from Mr. Yaeger indicating your participation in the program is required.*

Appendix B: Rubric

Tasks	Expected points (%)	Points achieved
Anecdotal records - Write the dates and time at your assigned school, subject/benchmarks covered in lessons, and number of students/class you are facilitating. In addition, updated common core standards for the Math & Science section of the program.	10	
Summary - Write a summary about your experience with TLI and the assignment and school, brief information about the class, LEP or ESE strategies if required. Type of assessments used in this program. How was Technology and Science integrated into this program? Five cited empirical research studies about STEM, partnership with nonprofit organization, and clinical experience. The paper must be written in APA format & minimum grammatical errors (1000 words).	8	
Letter or Certification from the school with the school letter or letter from TLI.	2	
Total points	20%	