

Building a Firm Foundation: Preparing Pre-K–4 Teachers for Integrative STEM Pedagogy

by Sharon A. Brusic, Millersville University of Pennsylvania; Nanette Marcum-Dietrich, Millersville University of Pennsylvania; Jennifer Shettel, Millersville University of Pennsylvania; & Janet White, Millersville University of Pennsylvania

Abstract

Preservice teachers in early childhood (pre-K–4) education teacher preparation programs typically experience content-specific pedagogy courses that operate in isolation from each other. In addition, preservice teachers are rarely given the opportunity to learn about integrative teaching in science, technology, engineering, and mathematics (STEM). In this article, the authors describe how Millersville University of Pennsylvania, a midsized regional public university in the Mid-Atlantic Region, addressed this issue in their teacher preparation program by creating an integrative STEM (iSTEM) minor that provided preservice teachers with five additional courses that explored how to implement STEM in early childhood classrooms in developmentally appropriate ways with a design-based pedagogy. This article introduces the program, including the specific coursework that preservice teachers engage in as well as other programmatic features that contribute to the success of the minor in increasing the confidence and skill levels of future teachers in successful STEM integration techniques. Photographs and artifacts are included to provide readers with a clearer picture of the types of learning activities and assignments in which students engaged. The article concludes with qualitative comments from students who participated in this program.

Introduction and Program Context

Buildings, towers, bridges, dams, and other structures are constructed on foundations that provide stability for the superstructures. Permanence and safety are directly tied to the strength of the structure's foundation. The foundation plays a key role in distributing the structure's weight and helping to ensure that the underlying soil is not overloaded, which can cause structural failure. The structural foundation is analogous to the pedagogical foundation upon which Millersville University faculty built a new, optional Integrative Science, Technology, Engineering, and Math (iSTEM) Education Methods program for early childhood (pre-K–4) preservice teachers. Millersville University is a student-focused university in Lancaster County, Pennsylvania with approximately 6,600 undergraduates and about 1,000 graduate students. It has a long tradition in teacher education as it was founded in 1855 as the first Normal School in Pennsylvania. Today, Millersville University offers almost 70 baccalaureate programs, including a wide range of teacher preparation programs.

This iSTEM program for early childhood preservice teachers was launched in 2015 after a 3-year curriculum development process involving significant collaboration between faculty members across colleges and departments at the university. The program is managed by faculty members with expertise in technology and engineering education, and a key innovative aspect of this program is the emphasis on design-based learning and pedagogy, which is a hallmark of this discipline (Warner, 2011). Faculty with math education, science education, and early childhood education expertise also teach courses in this minor. Millersville University's iSTEM minor reflects the definition of iSTEM as described by Sanders (2009) and defined by Wells and Ernst:

Integrative STEM Education is the application of technological/engineering-design-based approaches to *intentionally* teach content and practices of science and mathematics education concurrently with content and practices of technology/engineering education. Integrative STEM Education is equally applicable at the natural intersections of learning within the continuum of content areas, educational environments, and academic levels. (Wells & Ernst, 2012; as cited in Wells, 2013, p. 29)

At Millersville University, the overall goal of the iSTEM program is for preservice teachers to develop the knowledge, skills, competencies, and habits of mind that will best prepare them to use integrative and experiential teaching–learning approaches to enhance their students' learning of STEM as well as other areas of the curriculum. The iSTEM program engages these future teachers in experiences to promote their mastery of STEM academic standards and skills and to help them grasp the significant role of teachers in helping to shape children's conceptions of STEM and interest and motivation in STEM subjects.

Students preparing to be pre-K–4 teachers at Millersville University complete a typical undergraduate curriculum consisting of about 120 credits. Within these 120 credits, preservice teachers must take courses in all content areas to prepare them to be well-rounded and complete a series of professional courses to prepare them to be teachers, including pedagogy courses that address curriculum and instruction in the major content areas (including science and math) and field experiences to develop firsthand experience working with children. Apart from a course in instructional technology, rarely do preservice teachers take any courses in the technology and engineering disciplines, two of the key components of STEM education. Therefore, it would be unrealistic to expect these program graduates to be effective iSTEM educators.

Importance of This Program

Numerous studies have found that many preservice elementary teachers lack confidence or interest in science and mathematics (e.g., Bergman & Morphew, 2015; Howitt, 2007; Vinson, 2001; Westerback, 1984), and there is evidence that teachers' anxiety negatively affects their students (e.g., Beilock et al., 2010; Bursal & Paznokas, 2006). Furthermore, research has

shown that there are benefits to integrating STEM learning in early childhood education. In their report titled *STEM Starts Early*, McClure et al. (2017) noted: “We now know that very young children are much more capable of learning about STEM concepts and practices than originally thought, resulting in missed opportunities for early learning when we wait to start STEM education until later” (p. 14).

How can we expect to inspire the STEM workforce of the next generation if their introduction to these subjects in the early elementary grades is through teachers who lack enthusiasm and confidence in teaching iSTEM? Currently, there are many efforts to improve iSTEM education for practicing teachers, but there are still few opportunities in teacher education institutions for preservice teachers to develop the skills, expertise, and confidence in iSTEM teaching at the pre-K–4 grade level. Most preservice teacher education programs offer little or no exposure to technology and engineering education (the *T* and *E* of STEM) or to iSTEM coursework specifically. This is a significant missed opportunity that has long-term effects on the STEM workforce pipeline. There needs to be a better way to prepare dynamic and passionate teachers to effectively integrate iSTEM subject matter using developmentally appropriate pedagogy for young children. The program described here is one attempt to address this issue through an innovative sequence of courses and professional development (PD) opportunities.

Preparing future pre-K–4 teachers is different from preparing content-focused teachers of STEM subjects in middle school and high school. Early childhood educators have the responsibility of teaching nearly the entire curriculum in their self-contained classrooms. Although there may be teachers who are content experts for some subjects such as art, music, and physical education, rarely do schools have the resources to provide teacher experts in STEM subjects, particularly at the pre-K–4 level. Hence, the classroom teacher is the STEM teacher, and this person is ultimately responsible for designing and delivering the curriculum in all STEM subjects as well as other curricular areas such as English language arts and social studies.

The reality is that many early elementary teachers are unprepared to integrate STEM in the pre-K–4 classroom (McClure et al., 2017; Rose et al., 2017). There is, however, some support showing a positive effect on preservice teachers’ attitudes toward STEM teaching when provided with STEM mentoring in a problem-based learning environment (Caliendo, 2016). Early childhood educators are often attracted to this teaching level because of the emphasis on content areas of interest (particularly reading and writing) and their innate desire to work with very young children. Furthermore, mathematics is typically taught as an isolated subject area, and there is little time for science instruction in Grades pre-K–4 (with virtually no time allocated for instruction in technology and engineering). Therefore, it should be no surprise that there has been little headway in changing practice at this level. That is why Millersville University decided to take a different approach.

Historically, the pre-K–4 curriculum has been heavily focused on “the basics,” particularly reading, writing, and mathematics. In fact, according to Blank (2012), time spent on science in elementary classrooms is minimal. Blank (2012) reported two key research findings: (1) “Instructional time for science in the elementary grades has dropped to an average of 2.3 hours per week, the lowest level since 1988,” and (2) “aggregated national and state data indicate that less time for science is correlated with lower scores, accounting for approximately 12 points on the NAEP [National Assessment of Educational Progress] Science Scale at grade 4” (p. 3). In a more recent report, time spent on science instruction was reported to be equally dismal.

In 2018, grades K–3 self-contained classes spent an average of 89 minutes per day on reading instruction and 57 minutes on mathematics instruction, compared to only 18 minutes on science and 16 minutes on social studies instruction. The pattern in grades 4–6 is similar, with 82 minutes per day devoted to reading, 63 minutes to mathematics, 27 minutes to science, and 21 minutes to social studies instruction. (Banilower et al., 2018, p. 77)

Given the lack of time devoted to science instruction, teaching STEM content as a separate discipline is unlikely to be successful in the pre-K–4 classroom. Therefore, the Millersville University iSTEM program focuses on equipping pre-K–4 teachers with the content and skills necessary to integrate STEM across the pre-K–4 curriculum. In effect, it combines iSTEM content and pedagogy for a more robust learning experience, an approach that research suggests is effective (Mestre & Cocking, 2002).

Millersville University’s iSTEM minor for early childhood education majors was developed to build preservice teachers’ confidence and expertise in their ability to design an integrated curriculum that weaves STEM concepts into the existing curriculum through an inquiry and design-based approach that engages young learners. The emphasis is on process and integration instead of isolated STEM content. The aim is to help these beginning teachers seamlessly integrate STEM concepts and processes into the curriculum and learn to design instruction that is developmentally appropriate, using techniques that are effective with young learners. In effect, the program is meant to create a beautiful and educational tapestry—an interwoven connection of experiences and features that together help to create confident and enthusiastic pre-K–4 teachers who value iSTEM and are motivated to effectively integrate it into their classrooms.

The iSTEM program is an innovative approach to preparing early childhood teachers. The minor was purposefully designed to lay the foundation for these future educators who will subsequently influence generations of young children. Like the structural foundation, the pedagogical foundation in the iSTEM program is intended to lay the groundwork upon which these future teachers will build their competence and confidence in iSTEM over time. The iSTEM minor is more than a series of courses taken over the course of the 4-year program. The minor lays the foundation and helps to ensure that they are supported for lifelong iSTEM

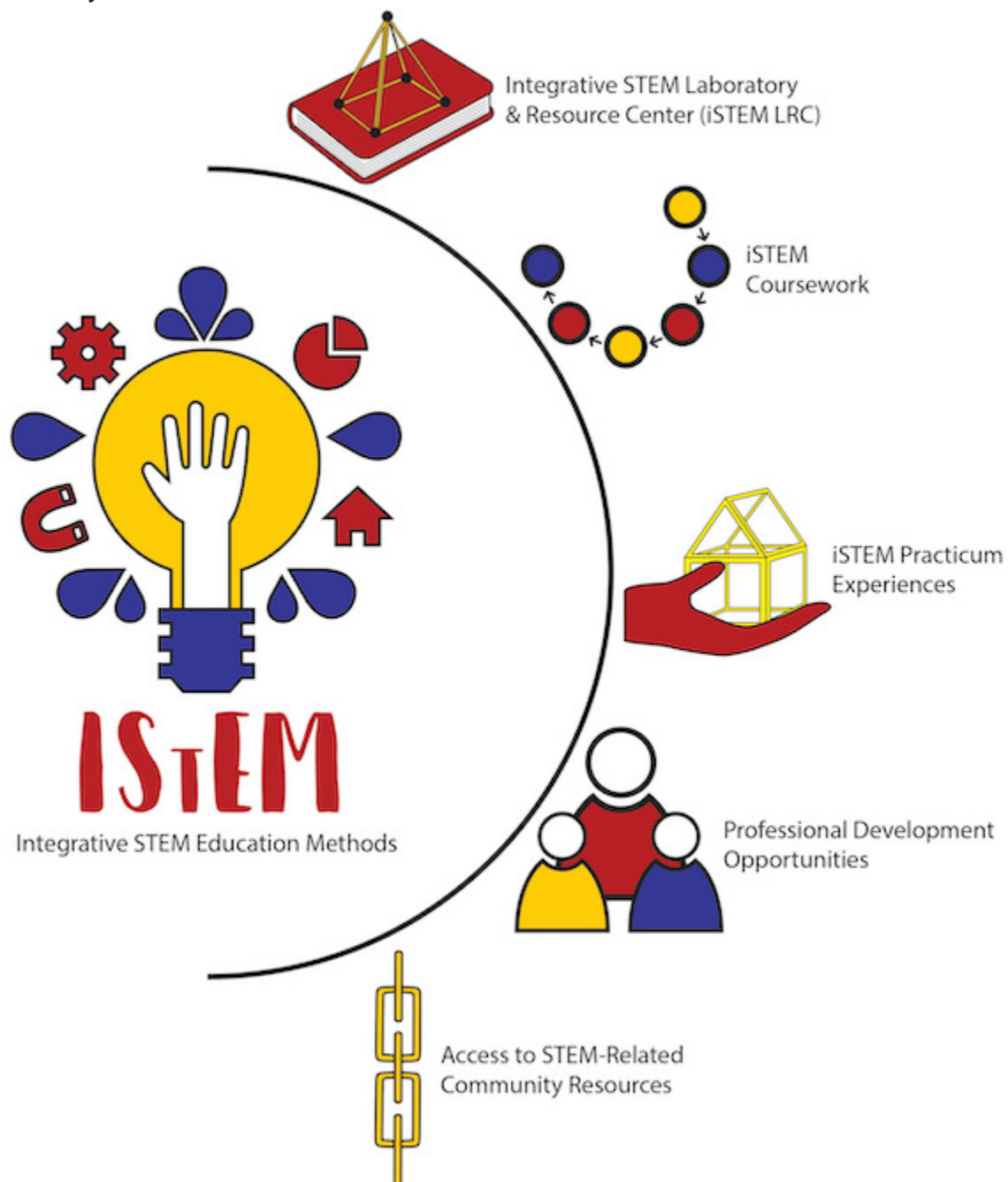
learning and teaching by engaging them in five key programmatic features that extend beyond coursework alone. This combination of integrative coursework with additional programmatic features is what makes this program stand out from others. Moreover, the central role of the *T* and *E* of STEM in this program provides iSTEM students with important content and pedagogy that is often missed in traditional teacher preparation programs at this level.

Five Programmatic Features

Millersville University's iSTEM minor is built on five research-based programmatic features: (1) the Integrative STEM Laboratory and Resource Center (iSTEM LRC), (2) iSTEM coursework, (3) iSTEM practicum experiences, (4) PD opportunities, and (5) access to STEM-related community resources (see Figure 1).

Figure 1

Five Programmatic Features of the Integrative STEM Education Methods Minor at Millersville University



iSTEM Laboratory and Resource Center (iSTEM LRC)

According to the 2014 position statement on science education early childhood from the National Science Teachers Association (NSTA)—now known as the National Science Teaching Association—which was also endorsed by the National Association for the Education of Young Children, “learning science and engineering practices in the early years can foster children’s curiosity and enjoyment in exploring the world around them” (p. 1). Furthermore, NSTA’s 2018 position statement on elementary science education “recommends the involvement of all education stakeholders to provide effective and

equitable instruction, materials, environment, and opportunities so that all students may succeed.” The iSTEM LRC was developed with this in mind. It is a hands-on laboratory space that provides future teachers with ample opportunities to engage with tools, materials, kits, and projects that might be applicable to the early childhood classroom, including robots, construction kits, electricity-based kits, modeling materials, 3D printers, laptops, tablets, and much more (see Figures 2 and 3). The emphasis is on how to use these resources to promote problem-solving and design thinking with young children. The iSTEM LRC also includes a collection of STEM-focused children’s books and some iSTEM curricula such as the *Engineering is Elementary* curriculum (Museum of Science, 2022). The iSTEM LRC was designed as one of the primary spaces for teaching some of the iSTEM courses as well as a space for students to use for investigation, practice, and curriculum development during open lab hours. Students’ use of the space was tracked through a check-in system from February 2017 through February 2020. During this time frame, it was documented that 49% of the iSTEM students visited the iSTEM LRC during open lab hours. It is important to note that some iSTEM students use the open lab as part of their course requirements. For example, students might visit the iSTEM LRC to work on a curriculum project for a STEM class or log hours in the iSTEM LRC to meet a course expectation to explore STEM tools.

The iSTEM LRC is an approximately 1,000-square-foot facility housed in the Department of Applied Engineering, Safety, and Technology at Millersville University, home to the iSTEM minor. The facility has an adjoining classroom space to seat 24 students, making it ideal for integrating with iSTEM coursework that combines hands-on design and problem-solving with pedagogical lessons and discussions, which are essential components in the preparation of future teachers.

Figure 2
A Student Uses Squishy Circuits in the iSTEM LRC

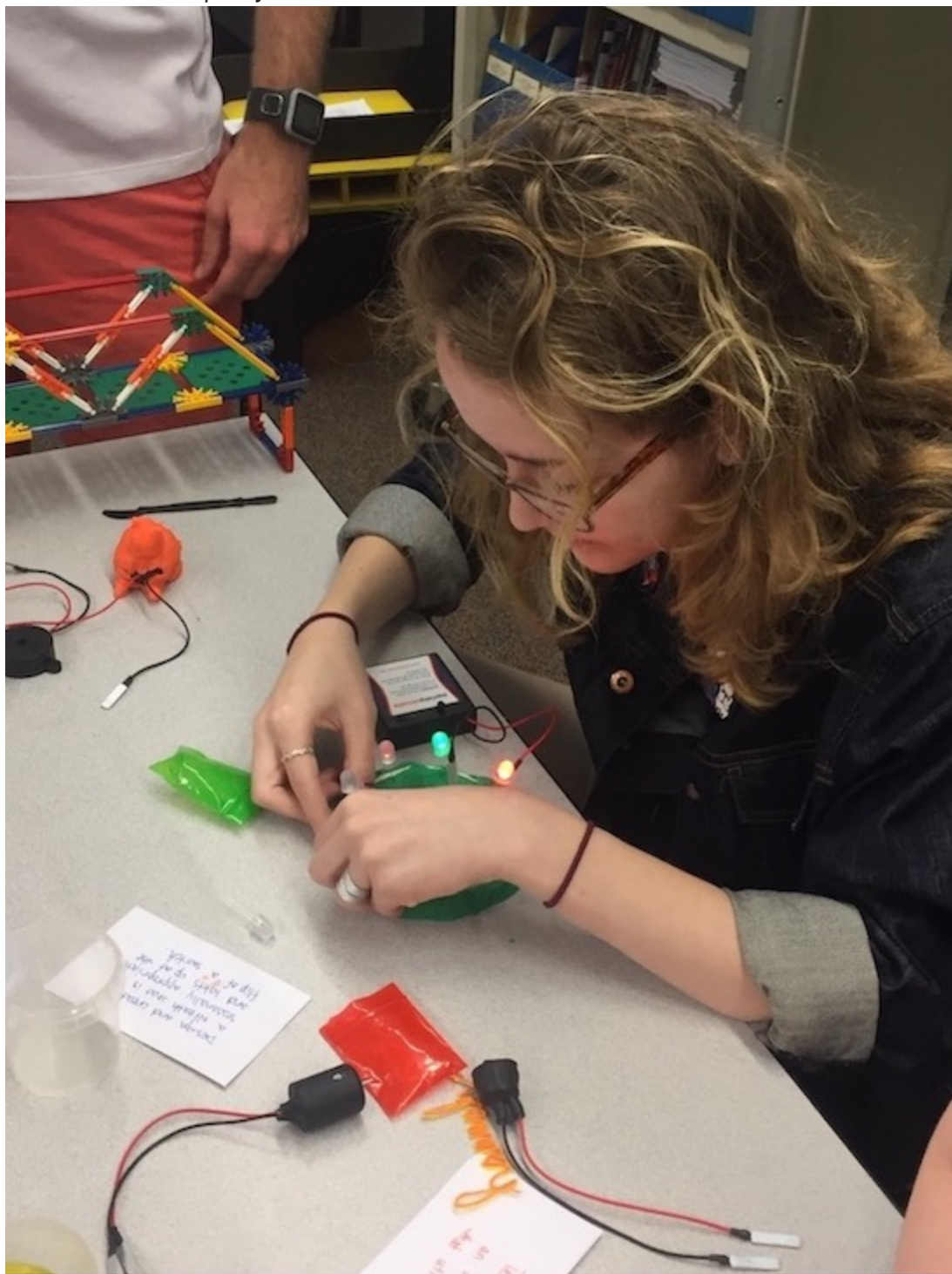
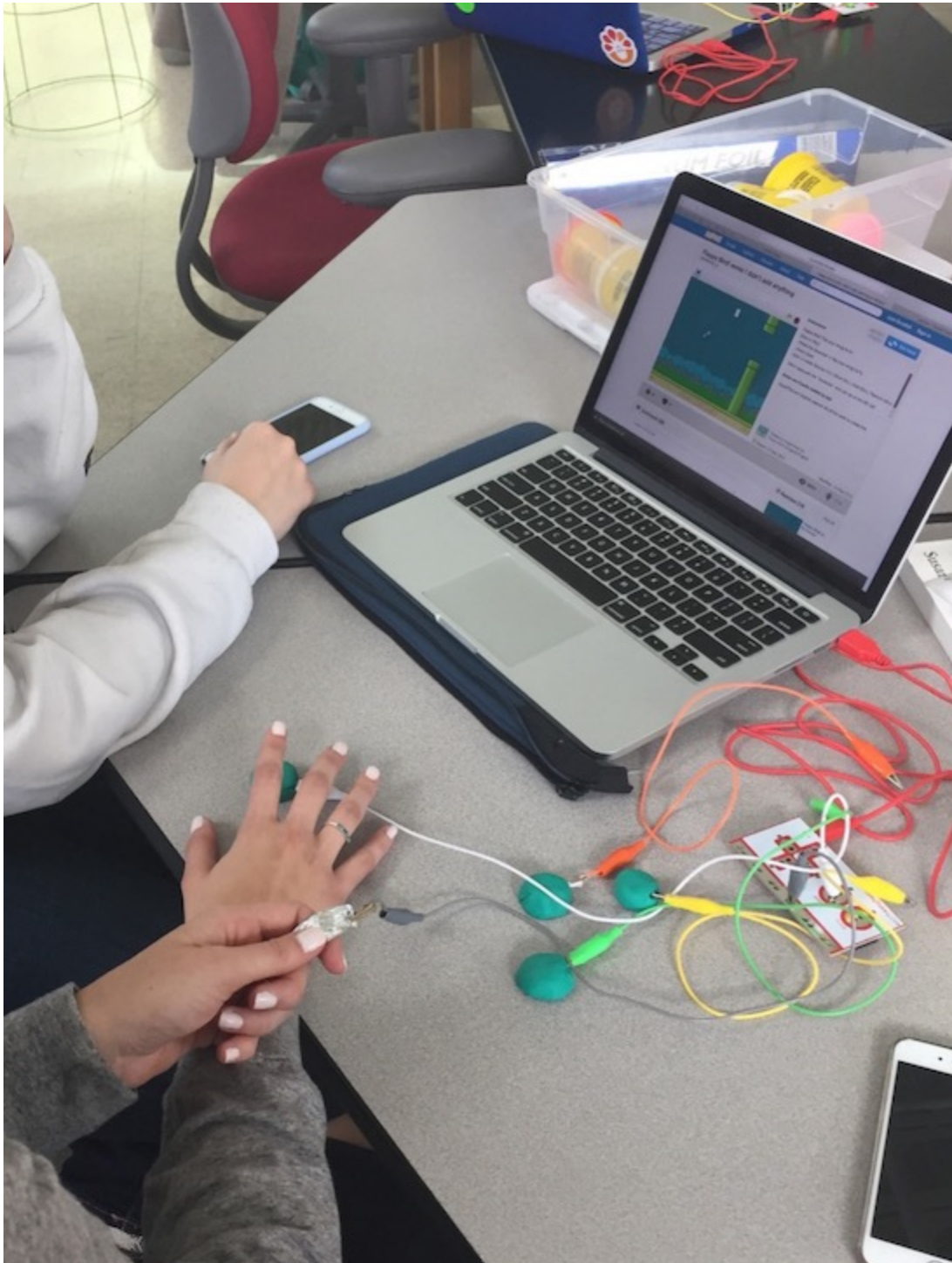


Figure 3

Makey Makey Kits Enable Students to Explore Computer Control in the iSTEM LRC



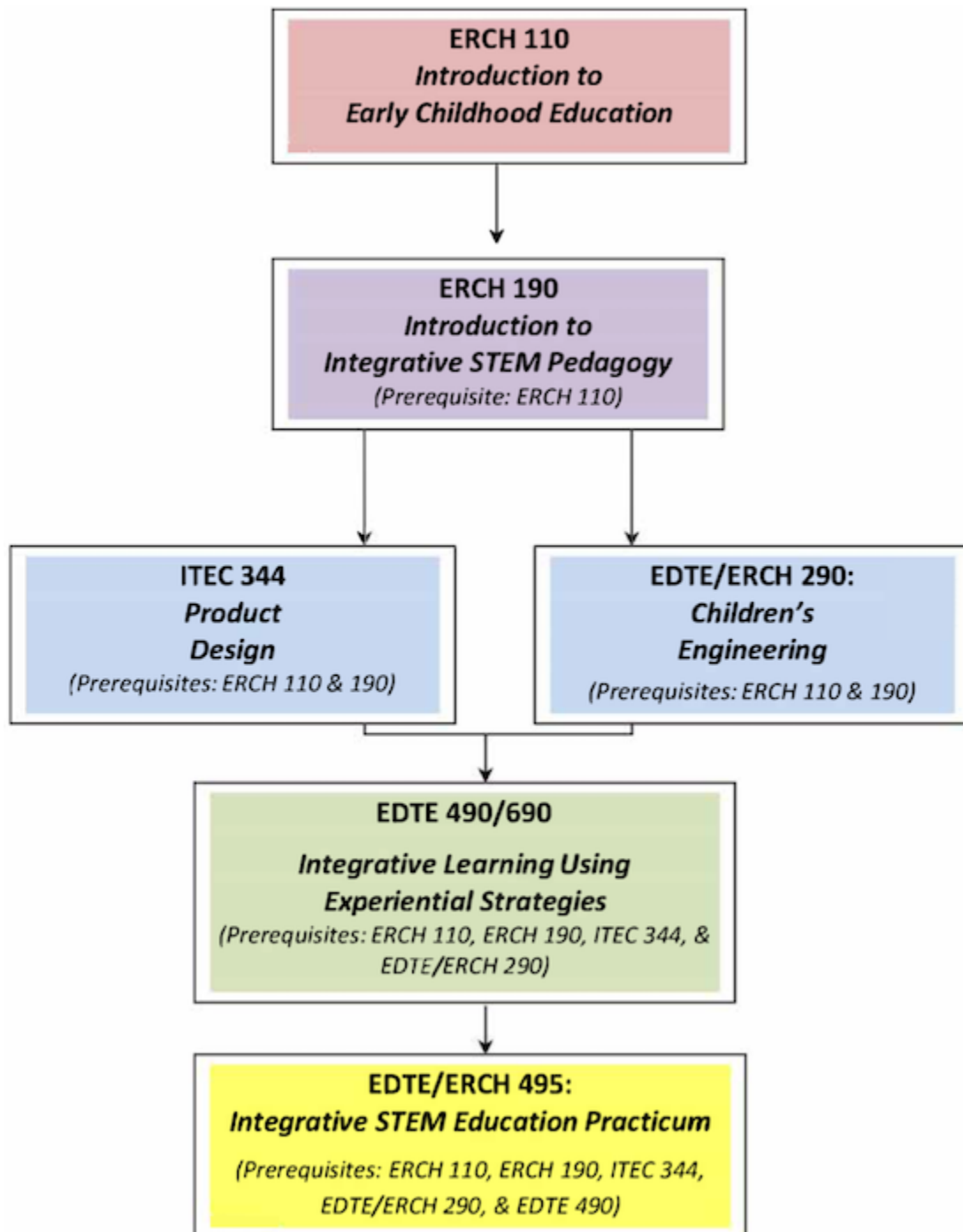
iSTEM Coursework

The iSTEM minor comprises a sequence of six required courses (3 credit hours each for a total of 18 credit hours) that are intended to better prepare future educators to plan, implement, and assess integrative STEM education programs and practices at the pre-K–4 level (see Figure 4). Students in this minor are placed in a cohort when they sign up and progress through the courses over about 3 years. The first five courses are offered once per

academic year during the fall or spring semesters; however, the final course, Integrative STEM Education Practicum, is only offered in the first summer session (May–June). The minor is optional for students, and no minor is required in this major. Students who complete this minor are also eligible to apply for an additional Integrative STEM Education endorsement on their Pennsylvania teaching certificate. The Millersville University iSTEM minor was approved for Early Childhood Education (ERCH) majors (pre-K–4) and dual ERCH and Special Education (ECSP) majors (pre-K–8), and the program commenced in June 2015.

Figure 4

Flow Chart of iSTEM Minor Coursework



It should be noted that all pre-K–4 preservice teachers, as part of their major program of study, must complete the mathematics and science credits required for their major and the university’s general education curriculum. STEM-related major requirements include two mathematics courses, two science courses, one mathematics pedagogy course, one science pedagogy course, and one course in instructional technology. These individuals do not have any required content courses taught by technology and engineering specialists (e.g., courses in product design, computer-aided drafting and design, manufacturing, or robotics). Students may have had a short experience with technology or engineering in middle school, but it is unlikely that many had any technology or engineering courses in high school. The iSTEM minor was designed to bridge this gap and places the focus on how to integrate content from all four STEM areas (plus other areas such as social studies, literacy, or art, as appropriate) in order to develop the planning, teaching, and assessment strategies needed to successfully implement this curriculum in Grades pre-K–4. This unique curriculum sequence places emphasis on building preservice teachers’ confidence and deepening their understanding of mathematics and science through a novel and integrative, experiential approach combined with technology and engineering. Whereas all early childhood education graduates are certified to teach science, mathematics, and other pre-K–4 subjects, students who choose this minor will be better prepared to do so because of the additional attention and focus on all iSTEM areas through an integrative approach. Students generally take these iSTEM minor courses starting freshman year and continuing through junior or senior year, depending on when they add the minor. To complete the minor without adding additional semesters, students often enroll in additional courses in some semesters, up to 18 credit hours. Students must also enroll in one summer session course because the Integrative STEM Education Practicum course is only offered in the summer.

The iSTEM program course sequence was designed to promote subject matter integration by example, showing future teachers how to effectively integrate content to promote their students’ STEM learning and achievement. Through a combination of professional and experiential courses and developmentally appropriate field experiences working with young students, the preservice teachers build their own competence and confidence with STEM. The STEM-focused courses are integrative in nature with a conscious attempt to knock down the barriers between subject matter to find connections, build understanding, and promote teacher confidence in STEM. This sequence aims to better prepare preservice teachers as integrative STEM teachers and leaders at the pre-K–4 level (see Table 1).

Table 1*iSTEM Course Descriptions*

Course	Description
Introduction to Early Childhood Education	This required course for all elementary majors provides an overview of early childhood education. Historical, theoretical, and philosophical influences on past and current approaches to teaching young children are traced and analyzed. The course introduces students to the early childhood education profession, analyzes the development of young children (birth–age 9), emphasizes developmentally appropriate practices, and provides an overview of effective curriculum, instruction, and assessment of young children. In the concurrent field experience, students reflect on their ability to cope with classroom reality as they affirm their choice of teaching as a profession.
Introduction to Integrative STEM Pedagogy	The first STEM-focused course in the sequence sets the foundation for understanding and appreciating STEM education by helping teacher candidates to grasp the importance of iSTEM for young learners. This course introduces teacher candidates to some of the research and best practices of STEM education and includes initial iSTEM learning experiences.
Product Design	The Product Design class engages learners in the “designerly” approach to learning (Cross, 2006) in which students engage in open-ended design and problem-solving in order to build important habits of mind required of an integrative STEM learning approach (e.g., persistence, communication, applying STEM knowledge, creativity, or design). This course emphasizes collaborative problem-solving and integrating STEM concepts through problem-based and project-based learning.
Children’s Engineering	Students in Children’s Engineering are immersed in hands-on, experiential learning activities that help them to apply their math and science understanding and build a deeper understanding of concepts such as electricity, mechanisms, fluidics, computer control, and structures that would be an integral component of an iSTEM education approach.
Integrative learning Using Experiential Strategies	This fifth course in the iSTEM minor sequence builds on the prior courses and helps future teachers to design, implement, and assess instruction and learning activities for early childhood learners that integrate content from all STEM areas, plus other areas of the curriculum as appropriate, including literacy, language, social studies, physical education, and the arts. Students evaluate and develop curriculum materials that exemplify sound practice in integrative STEM education. Students in this curriculum-focused course research and plan an iSTEM unit of instruction that incorporates developmentally appropriate STEM content and pedagogical approaches, as well as integrative learning strategies that will actively engage early childhood learners in developing their STEM understanding.
Integrative STEM Education Practicum	The final course is a culminating experience that engages preservice teachers in applying everything they have learned while working with pre-K–4 students. Teacher candidates in this course engage in field experiences to develop and use integrative STEM education curriculum materials and strategies with young students in an authentic setting (e.g., after-school program, weekend workshop, or evening program in a school or informal setting). Through analysis and reflection under the guidance of their professor, they see firsthand how to effectively plan, implement, and assess an integrative STEM education approach.

iSTEM Practicum

Field experiences are well documented as an effective means of preparing teachers. Preservice teachers in teacher preparation programs are regularly involved in field experiences to some degree, and there are numerous studies that reinforce the value of these activities (e.g., Aiken & Day, 1999; Cooper & Nesmith, 2013; Darling-Hammond, 2010). The iSTEM-focused practicum is another programmatic feature, and it serves as the field experience component in which preservice teachers benefit from applying what they've learned about the iSTEM curriculum, planning, and assessment while working with children. This field experience, which is embedded in the 3-credit hour capstone course (Integrative STEM Education Practicum), engages preservice teachers with pre-K–4 students and serves as the culminating experience for iSTEM minors, as noted in the previously described course sequence (Figure 4 and Table 1). This practicum experience is typically designed in collaboration with a school or informal learning organization to provide the iSTEM preservice teachers with an authentic iSTEM teaching experience in which they can practice applying integrative pedagogy. During a typical practicum course, candidates are at their field sites every day for 10–14 days (1.5–2 hours each day). For most practicum students, this occurs somewhere between early field experiences and student teaching.

Examples of field-based experiences that students have participated in include a collaboration with a local urban school district to provide an after-school STEM program, partnering with the local YWCA nonprofit organization to offer an after-school STEM program as part of their regular childcare services, collaborating with the Boys and Girls Club nonprofit organization to offer STEM programming, and working with Head Start programs to offer STEM instruction as part of their early childhood education program serving children from low-income homes. During the peak of the COVID epidemic, practicum students developed a remote learning at home option for students, which included mailing a box of supplies to each child. Children were recruited to participate through a variety of means, including a collaboration with the Lancaster Science Factory, a local science learning center. In every case, the iSTEM students design and implement curricula that reflect what they have learned through this integrative program and cater to the needs of the populations they serve (see Figures 5 and 6).

Figure 5

A Child Completes a Science Experiment at Home When STEM Fieldwork Had to be Completed Remotely During the COVID Shutdown



Figure 6

An iSTEM Minor Works With a Young Child Using Makey Makey and Scratch Software to Solve a Problem



iSTEM Professional Development Opportunities

To highlight the importance of ongoing learning, the Millersville University iSTEM program stresses engagement in PD opportunities. As noted by Power et al. (2002), “The combination of effective curriculum implementation and transformative professional development yields powerful learning for all” (p. 135). The iSTEM minor advisor regularly sends out email blasts to all iSTEM minors (currently at 90 students) promoting iSTEM programs and conferences of interest. STEM program faculty forward suggestions for opportunities to the advisor for dissemination. Some of these optional workshops focus on additional training for some of the STEM resources in the iSTEM LRC (e.g., Edison robots, Code.org training, Cricut machine, and virtual reality). Students are also encouraged to engage in professional conferences such as the Children’s Engineering Convention (Virginia), the NSTA STEM Expo, the International Technology and Engineering Educators Association Conference, National Council of Teachers of Mathematics conferences, the Technology and Engineering Education Association of Pennsylvania STEM Conference, the Pennsylvania Council of Teachers of Mathematics Conference, and the local STEMATHON (a collaborative conference supported by numerous education agencies in Pennsylvania). Some programming is planned and implemented by the Millersville University professors, but there are numerous other opportunities promoted, particularly through remote learning venues.

Over the 3-year period between 2017–2020 during which data were collected, 81% of iSTEM students chose to attend at least one project-sponsored STEM PD opportunity, which included on-campus STEM workshops, participation and travel to STEM conferences, and voluntary participation in iSTEM LRC open lab hours, and 59% of iSTEM students attended at least one community-based STEM PD event (see Table 2).

Table 2

Student Engagement in STEM PD Opportunities From February 2017–February 2020 (n = 138)

Event sponsor	# of iSTEM students participating	Total # of iSTEM students participating in PD
Project-sponsored events	112 (81%)	121 (88%)
Community-sponsored event	81 (59%)	

Note. Project-sponsored events included on-campus events, university-sponsored travel to STEM conferences, and iSTEM LRC attendance.

In addition, iSTEM minors are encouraged to join local student chapters of professional educator organizations such as the Technology and Engineering Education Collegiate Association at Millersville University (TEECA@MU), Mathematics Educators at Millersville University (MEMU), or the Pennsylvania Association for Education Communications and Technology (PAECT) at Millersville University and get involved in their meetings and PD activities. For example, the TEECA@MU organization attended a regional conference that involved students in a K–5 STEM competition for preservice teachers, and MEMU sponsored some workshops on coding using Texas Instruments handheld devices.

Figure 7

Students Attend a PD Workshop to Learn About Stream Studies Delivered by the Stroud Water Research Center



Access to STEM-Related Community Resources

Many communities are filled with STEM-related resources that have the potential to build a deeper understanding of concepts. Community resources can take many forms and are a valuable addition to any educator's teaching toolbox.

In order to prepare teachers to meet the challenges of a rapidly changing human landscape, we, as teacher educators, need to provide authentic, and meaningful experiences that are situated in place, build community, and show pre-service teachers that they have resources and partners eager to support the educational mission of community schools beyond the walls of their school buildings. (Adams et al., 2014, p. 18)

The Millersville University iSTEM program coordinators are attentive to creating a network of community resources that would interest early childhood iSTEM educators and have the potential to positively impact their understanding of STEM content and pedagogy. Where appropriate, these resources are incorporated into required iSTEM courses, such as taking a field trip to the local, hands-on STEM learning center or collaborating with our local education service agency to develop STEM activities for a special STEM Bowl for local youth (Brusic et al., 2020). Most community resources, however, are promoted through communications with iSTEM minors, including email blasts and announcements through a learning management system. Students are encouraged to take part in volunteer opportunities at local STEM-focused organizations (e.g., Lancaster Science Factory, North Museum of Nature and Science), environmental education events sponsored by Lancaster County Parks (e.g., Owls & Owl Pellets, Bugs and Black Lights, Nature Photography Hike), online webinars and workshops (e.g., sponsored sessions by PennState Extension, Pennsylvania Department of Conservation and Natural Resources), and other opportunities.

Excellence in iSTEM Recognition Program

A recognition program called Excellence in iSTEM was introduced to motivate students and to recognize those who go above and beyond in terms of engaging in PD and community-based activities. Students receive this designation once they earn an established number of points and are then eligible to wear a special graduation cord with their commencement garb acknowledging this achievement. All activities are documented through an online submission form and must be above and beyond class requirements. The form gathers information about what they did and requires them to identify activities from the event and how those activities impacted their personal PD. For example, students could earn one point for each hour they visit the iSTEM LRC to explore the tools, materials, and kits there during an open lab. They could earn two points if they served as a judge for a STEM-related competition. Implementation of this recognition program resulted in a clear increase in student engagement and participation in these types of learning opportunities outside the curriculum.

This program was implemented in 2018 to encourage more students to participate in the optional PD events that are offered throughout the academic year. To date, 81 students in the iSTEM minor have utilized this points-earning system, and 32 students have met the criteria to earn the honor cord upon graduation. The Excellence in iSTEM program was the brainchild of two of our faculty members, and it appears to be successful in motivating students to be more engaged in PD experiences.

Evidence of Impact

The overall goal of the undergraduate iSTEM program described here is to prepare future early childhood educators to develop the knowledge, skills, competencies, and habits of mind that will best prepare them to use integrative and experiential teaching–learning approaches in order to enhance their students’ learning of STEM, as well as other areas of the curriculum. There is some evidence that the iSTEM program approach is impactful.

As of fall 2020, there were 732 undergraduate students enrolled in the early childhood teacher preparation program. Of these, 86 students were enrolled in the iSTEM minor, which constitutes approximately 12% of the early childhood education majors on campus. The iSTEM minor is the most popular minor for early childhood education students. Art and psychology are the next most popular minors, with just six students in each (less than 1% in total). Most (82%) early childhood education majors do not choose to add a minor.

Another indicator is the extent to which iSTEM minors became engaged in PD above and beyond course requirements. Over a 3-year period during which data were collected through surveys and interviews as part of a research grant, 88% of iSTEM students reported having participated in STEM activities in their personal and professional lives, and 21% of iSTEM students participated in STEM-related conference travel. Many of these students even served as conference presenters to share their newfound expertise.

Students’ feedback about the iSTEM minor has also been particularly positive. When asked what they learned from their iSTEM experiences during an interview, one student said, “I want to make my lessons more integrative than compartmentalized because . . . the real world isn’t in boxes, and that’s how kids in some schools are learning.” Another interviewed student talked about how the iSTEM experiences affected her teaching perspective. She stated,

I’ve been intentionally trying to incorporate the technology, engineering, and math part into my science lesson and then also some literacy and some social studies just because I think now my philosophy of education has changed as well. All of the content areas together really build off of each other, and it can only make my lesson stronger if I incorporate more than one subject.

Program graduates have also reached out to us after they began their teaching careers. A spring 2020 graduate wrote in an unsolicited email to her iSTEM professors,

I’m reaching out to you today to share some exciting news. I’m sharing this with you because I want you to know how much everything you’ve done and continue to do for your students is making a huge impact on our lives, and I want to thank you for your part in helping me get to where I’m at today!

She went on to explain that she is currently a fourth-grade teacher, however her principal informed her that she would be leading a new STEM program at the school that would reach every student in the elementary school. Another iSTEM program graduate sent an unsolicited email about 1 year after his graduation in 2019:

I want to express my gratitude for all that you did for me and my peers at Millersville University. The STEM minor completely changed the way I think about education I have integrated some [design] challenges into my own instruction and have even helped other, not-as-new-as-me, teachers implement them in their rooms too. I think, so far, that I have been successful at cultivating a desire to investigate, be curious, and be creative. I have received many thankful messages and compliments from parents about how they are amazed at the conversations they hear between their students and their friends or how their child has grown a love for science. I attribute that to you and the others at Millersville University I hope that the program continues to excel and provide these types of learning opportunities for many more to come. It is amazing that, through each student you teach, you can reach so many more who they teach.

Conclusion

The iSTEM minor targets Millersville University undergraduate students as part of their early childhood teacher preparation program. Participating in this minor prepares preservice teachers with the knowledge, skills, and confidence to integrate STEM across the pre-K–4 curriculum and is dependent on the confluence of five programmatic features. As described, the program is much more than a sequence of courses. Instead, the program intentionally builds students' expertise through the combination of structured coursework, authentic experiences with children, iSTEM LRC engagement, PD opportunities, and engaging with community resources. Altogether, these program components help to build a firm foundation for novice educators and contribute to building their expertise and strengthening their resolve to improve iSTEM education for early childhood learners. Moreover, Millersville University faculty are hopeful that this strong foundation will serve them well as they move forward in their teaching careers and provide the leadership needed to effectively integrate STEM into pre-K–4 classrooms.

Acknowledgment

This material is based upon work supported by the National Science Foundation under Grant No. DUE-1611652. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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