

Providing Support to High School STEM Teachers at Underrepresented Schools Through a Yearlong Professional Development Initiative (WIP, Diversity)

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I am the Industrial and Engineering Technology Department Head at Southeastern Louisiana University. I received my first two degrees in Mechatronics Engineering in Jordan and Malaysia, respectively. In 2012 I graduated from UNLV with Ph.D. in Mechanical Engineering and immediately joined Southeastern as an Assistant Professor. I work in the area where Mechanical meets with Electronics to produce a nice mix called Mechatronics. I enjoy working with students while teaching in classroom, or in the lab doing research.

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Abstract

In addition to being an employment requirement for in-service high school educators, professional development (PD) workshops in STEM fields are vital for keeping up with new innovations in both theory and practice. Integrating cross-cutting engineering concepts into a PD STEM program provides a unique opportunity for both teachers and students. Students gain a deeper understanding of individual concepts and the relationship among the components of STEM. Teachers benefit from demonstration of how this integration of concepts can be practically carried out in their classrooms. The goals of the PD institute were to 1) integrate industrial technology, engineering technology and computer science constructs into core math and science high school curriculum (Physical Science, Biology, Chemistry and Physics); 2) advance teacher knowledge in the core science subjects with emphasis on misconceptions; 3) introduce/reinforce the engineering design process; and 4) due to COVID-19 constraints, to introduce teachers to online simulation platforms for at-home and in-class discovery of scientific concepts. Delivered as a six-day workshop in Summer 2020, the PD institute continued throughout the school year to offer continued support and form a Professional Learning Community (PLC). Due to restrictions from COVID-19, the entire workshop was delivered virtually and instruction was offered to assist with remote delivery of classes and science labs in the upcoming school year. The program covers multidisciplinary engineering science and education technology topics including misconceptions in physical science, misconceptions in biological science, visual programming, CAD and 3D printing, electrical circuit simulation, and overview of online teaching technologies. In addition to instruction and continuing education credit, the teachers received classroom materials to support them in delivering these STEM contents in their schools including a 3D printer for each participating school. This paper represents the current work in progress as part of a comprehensive initiative, which also includes a ten-day summer program for high school students, to serve diverse students and educators from underrepresented communities.

Keywords: STEM, Pre-College, In-Service Teachers, Professional Development, Interdisciplinary Engineering, experiential learning, hands-on, simulation

Literature Review

The effectiveness of STEM teachers has been directly related to teacher's self-efficacy. Teachers with many years of service were trained using traditional methods that did not include an interdisciplinary approach to STEM education. Many teacher preparation programs continue the "traditional" approach to science education, an approach that unfortunately does not focus on integrating the natural sciences with mathematics, engineering and computer science. An increase in the number of teachers certified via alternative certification programs has also increased the need for STEM focused professional development. (Beaudoin et al. 2013) STEM focused professional development has been shown to have a positive effect on teacher self-efficacy. (Kelley et al. 2020) The need exists for professional development opportunities that incorporate STEM focused content. Successful STEM-focused professional development institutes have incorporated both pedagogical best practices and necessary STEM content knowledge. Approaches that incorporate content that is directly applicable to subject matter that teachers actually teach have been shown to be successful. (Hill et al., 2020) A multidisciplinary

approach to STEM education professional development meets a key need for in-service teachers. (Shernoff et al. 2017) The effectiveness of STEM focused professional development is amplified if a successful Professional Learning Community is formed. Successful PLC's allow teachers to interact and collaborate. (Vossen et al. 2019) The Covid-19 pandemic has created a need for modification in the delivery approach for professional development institutes. Professional development facilitators have been forced to rethink the model for STEM focused professional development. Virtual professional development with a STEM focus faces challenges that are not encountered in traditional face to face settings. These challenges require creative practices to overcome obstacles faced during implementation. (Brasili and Allen 2019)

Program Details

STILE-Ed Summer STEM Institute provided teachers with five days of interactive instruction on using the virtual Harvard LabXchange simulation platform for Biology and Physics, and also incorporated 3D Design & Printing and Computer Science. On the sixth day, teachers prepared a LabXchange pathway to use as a lesson plan for their students. Fourteen teachers and administrators from nine schools registered for the virtual STILE-Ed Summer STEM Institute. A total of eight participants from seven of the schools attended at least one of six institute days. from seven of the schools. The eight participants demographics shows seven identify as female and one male, six identify as Black/African American and two Asian American. The eight participants attended most of the sessions for the week and all completed a LabXchange pathway to be used with their students. This summer program allowed teachers to earn up to 24 CEUs with the possibility of earning another 24 CEUs by participating in the monthly PLC meetings.

Summer Program

The summer program included the following:

1) LabXchange. One of the main outcomes of the STILE-Ed Summer STEM Institute was the introduction of the Harvard LabXchange simulation platform, which allows teachers to create interactive content aligned to standards and facilitating student learning of concepts through laboratory virtual simulations that can be used for virtual and in-class learning. The platform provides free interactive lab simulations, which can also fill in where expensive lab equipment is not an option.

The final day of the summer workshop was dedicated to the creation of pathways by each participant. Participants were instructed to choose a lesson plan that they have implemented in the past. The lesson plan was used to generate a short pathway in the LabXchange platform. The requirements of the pathway were: Identify content standard(s) addressed; Identify learning objectives and outcomes; Identify misconception(s) associated with content topic; Utilize at least one resource that is not available in the LabXchange platform; and include an assessment. All participants chose a topic that was relevant to their content area. All eight teachers prepared a learning pathway in the platform for use in their classrooms this coming academic year. The pathways generated by each participant included the required elements. At the end of the final day a "pathway gallery walk" enabled each participant to showcase their completed pathway.

2) 3D Modeling & Printing. The module started with a short presentation on 3D printing technologies, the focus was on 3D modeling. 3D modeling is one of the key activities that integrates different science disciplines with 3D printing technology. For 3D modeling, teachers

were introduced to TinkerCAD, which is a free, cloud-based 3D modeling software that runs on any browser on any machine. Other methods and tools practiced by the teachers included converting 2D hand-drawings and 2D pictures into 3D models, using TurtleBlocks, TinkerCAD Blocks, OnShape CAD program, and desmos.com to develop 3D models. In the last hour of the program, few websites (Instructables.com, weareteachers.com, commonsense.org, createeducation.com, NIH, amtekcompany.com, NASA, Smithsonian museum, wpi.edu, Thingiverse.com) that have free 3D models available for different STEM disciplines such as engineering, physics, chemistry, biology, medicine, astronomy, etc. were presented to teachers. A sample template to help with developing a 3D printing project was provided as well.

3) Engineering Simulation through the AutoDesk simulation platform, TinkerCAD. Teachers were introduced to basics of circuits constructions and the simulation of Ohm's simulation through tutorials and simple exercises. A classroom was created in Tinker and teachers were given an access code to join the class, complete the assigned exercises, and save their work. Teachers were able to simulate circuits with several components virtually without the need of having the actual components or the fear of any hazard of electric shock. This allows teachers to implement these simulations in introducing the concepts of Ohm's law and similar concepts to their students remotely.

4) Remote class teaching technology. Teachers were introduced to 3 technology tools that can help them in their remote as well as in-person teaching. These tools included the famous online instant polling tool, Kahoot, the online instant response tool, mentimeter, and the online grading tool, gradescope. Each one of these tools provided extended full access to teachers till the end of the year 2020 because of the COVID-19 circumstances. Teachers learned about creating polls and quizzes through the 2 instant response tools. They also practiced by responding to some prepared polls and preparing their own.

5) Visual programming with Alice. Teachers were introduced to the visual programming language, Alice, and given insights on how it can be used in the classroom to introduce the constructs of coding and critical thinking skills in the STEM classroom. They were instructed to download and install Alice on their computer before the camp and practiced coding during the virtual session.

The Yearlong Program

The STILE-Ed STEM Institute continued through the 2020-2021 academic year. Two Saturday workshops were held in the Fall 2020 quarter (September 26 and November 14.) All eight participants attended both workshops. The September workshop was held virtually while the November workshop was held in-person on Southeastern Louisiana University Campus. During both sessions, participants were assessed using formative assessments to ensure high levels of understanding throughout and by the end of each session. The September workshop session introduced Electrostatics and Basic Electric Circuits and participants demonstrated understanding of all learning objectives listed as the workshop progressed. The November session was a hands-on 3D Design and Printing workshop using MakerBot Sketch 3D printers. By the end of the session, all participants were able to design and model a keychain using TinkerCAD, prepare the models for 3D printing using MakerBot Print software, and print the keychains on MakerBot Sketch printers. Follow-up workshops will continue to reinforce learning

and to support a classroom activity with students. Summaries of the workshops of Fall 2020 are presented below.

1) Exploring Misconceptions in Physical Science. Teachers explored several common misconceptions in physical science. Conceptual change in the classroom can be accomplished by applying constructivist learning theory to instructional practices. They explored approaches to conceptual change using simulation environments that are easily accessible to students. LabXchange pathway was created for the participating teachers and Louisiana science standards for different physics contents were discussed.

2) Exploring Misconceptions in Biology Teachers completed a variety of activities, including readings, Jam board discussions, short quizzes, videos, games and simulations. Most of the activities were included in a LabXchange pathway and faculty were continually available on Google Meet to provide an environment of guided inquiry.

Activities included two short readings addressing misconceptions about how evolution works. Teachers then moved onto LabXchange and completed a PhET “Bunny Simulation” and a detailed worksheet, which encouraged teachers to critically think about the various scenarios on the simulation. Teachers viewed a second video, “Mutation as a Source of Variation” by Khan Academy and played a game [7], “Be the Predator! Peppered Moths, Natural Selection in Action”. Teachers were then asked to explore “The Evolution Simulator, A More Complex Illustration” [8].

Outcomes

Feedback from the participants was collected qualitatively during the week-long institute and during the first fall Saturday meeting on September 26, 2020, after teachers had a few weeks to implement ideas into their classrooms.

Participants were asked to provide feedback regarding LabXchange at the first academic year follow-up meeting. Given the adjustments to the learning environment during this academic year several schools were unable to implement LabXchange at this time. However, at least two participants have actively implemented LabXchange in their schools. One participant has provided training to fellow teachers at their school. We are encouraging teachers to provide redelivery to colleagues when possible.

Teachers were very interested in the content matter in the Biology component, participated in all activities and readily shared their comments with university faculty who interacted with teachers throughout the day via Google Meet. When asked to share their thoughts on the module, participants mentioned that the module was relevant to their teaching, that they used some materials in their Fall classes and that they would share these materials with other teachers.

Feedback from participants in the Physics module indicated an interest in further investigating student misconceptions in their classrooms. One teacher indicated that they have used the conceptual approach as a foundation in their physics and chemistry classes. As requested, we will revisit the conceptual change model and its applications during an academic year follow up meeting.

Regarding the Computer Science module, at the first follow-up Saturday session, teachers were presented with a Jam board and asked to comment on their current use of the concepts presented in their classroom, or their plans for doing such moving forward. Three of the eight in attendance responded on the Jam board, indicating that while they intend to incorporate visual programming in their classes, they have not been able to do so yet and that additional training is desired.

The 3D Design and Printing was a successful workshop module that kept the participant active and engaged. The summer institute participants commented on the workshop and indicated 5 out of eight participants are “very interested” in learning advanced 3D printing subjects in the fall 2020 semester, great interest in incorporating 3D projects into their course, and continuing interest in the subject and demand for more advanced workshops on 3D printing.

The follow-up survey on Engineering and Virtual Technology reported that participants gained knowledge about multiple tools that they can use for simulating physics concepts in their remote class delivery. They also learned about using 3 technology tools for instant response and grading that can make their classes more interactive, engaging, and time and effort saving.

Future Work

It is planned to continue these workshops on a monthly basis and hold them onsite and/or virtual to discuss more STEM related topics that can help high school teachers in their delivery, promote and strengthen the student interest in STEM careers in their schools.

Acknowledgements

This camp is supported by LA GEARUP (Louisiana Gaining Early Awareness and Readiness for Undergraduate Programs), a federally funded national initiative that is supported by the U.S. Department of Education.

Bibliography

- [1] Beaudoin, Colleen, et al. “University Support of Secondary Stem Teachers Through Professional Development.” *Education*, no. 3, 2013, pp. 330-339.
- [2] Brasili, Alexandria, and Sue Allen. “Beyond the Webinar Dynamic Online STEM Professional Development.” *Afterschool Matters*, vol. 29, 2019, pp. 9-16.
- [3] Hill, Heather C., et al. “Professional development that improves STEM outcomes.” *Phi Delta Kappan*, vol. 101, no. 5, 2020, pp. 50-56.
- [4] Kelley, Todd R., et al. “Increasing high school teachers self-efficacy for integrated STEM instruction through a collaborative community of practice.” *International Journal of STEM Education*, vol. 7, no. 14, 2020, pp. 1-13.
- [5] Shernoff, David J., et al. “Assessing teacher education and professional development needs for the implementation of integrated approaches to STEM education.” *International Journal of STEM Education*, vol. 4, no. 13, 2017, pp. 1-16.
- [6] Vossen, T. E., et al. “Finding the connection between research and design: the knowledge development of STEM teachers in a professional learning community.” *International Journal of Technology and Design Education*, vol. 30, 2019, pp. 295-320.
- [7] <https://askabiologist.asu.edu/peppered-moths-game/>
- [8] <https://labs.minutelabs.io/evolution-simulator/#/s/2/about>

