Strengthening the STEM Preparation of Teacher Candidates Using the Online NASA Digital Badging System

Dr. Leslie Huling
Dr. Virginia Resta

Abstract

A lingering challenge in teacher education that has been exacerbated by the COVID-19 pandemic is how to provide teacher candidates with sufficient preparation in STEM education so that they can provide engaging STEM instruction that will inspire students to pursue additional STEM opportunities and career explorations. Many elementary teachers received very little STEM coursework in their university programs and thus feel unprepared to deliver a well-integrated STEM curriculum, and at the secondary level, often teachers certified in non-STEM fields find themselves assigned to teach one or more STEM classes for which they are unprepared. Because high-quality STEM instruction typically entails a great deal of hands-on learning, it has been challenging for all teachers to deliver their STEM instruction online when they had little advance planning time to transition to online content delivery when the COVID pandemic necessitated remote learning. This article advocates the use of a free, content-rich online STEM learning resource, the Digital Badging System provided by the NASA STEM Engagement & Educator Professional Development Collaborative, that can be used in teacher preparation to enhance the STEM background knowledge of preservice teachers and introduce teacher candidates to an online tool that they can later use with their own students.

Introduction

Teacher educators are frontline providers in supplying U.S. schools with the teaching workforce needed to staff our schools with high-qualified and dedicated professionals who will

help shape the next generation of American leaders and workers. The U.S. Bureau of Labor Statistics (BLS) 2019–29 employment projections show that occupations in the STEM field are expected to grow 8.0 percent by 2029, compared with 3.7 percent for all occupations. If this demand for STEM professionals is to be met, the United States would need to increase its yearly production of undergraduate STEM degrees by 34 percent over current rates to match the demand forecast for STEM professionals.

The challenge of increasing U.S., STEM degrees is not one that can be addressed by post-secondary education alone, as STEM identity formation starts long before students begin selecting career paths and college majors. STEM identity formation begins in the early grades and is nurtured by engaging, culturally responsive, STEM instruction in which students can be successful and envision themselves pursuing future STEM opportunities (Huling, 2022; Vincent-Ruz & Schunn, 2018). Teachers need academic preparation and teaching resources to be able to deliver engaging STEM instruction that will inspire students and put them on a path for future STEM pursuits, and this academic preparation of the teaching workforce begins with teacher educators.

Teacher educators can be instrumental in preparing teacher candidates with STEM content knowledge and the understanding of the important role they will play in giving students STEM experiences that instill their interest and confidence for future STEM endeavors.

Recent events stemming from the coronavirus pandemic have brought into sharp focus the need to prepare educators to be able to quickly adjust the curriculum to provide high-quality, engaging and authentic STEM learning experiences outside of the “normal” classroom context including increasing reliance on technology for curriculum delivery. In contrast to experiences that are planned from the beginning and designed to be online, emergency remote teaching

(ERT) is a temporary shift of instructional delivery to an alternate delivery mode due to crisis circumstances. It involves the use of fully remote teaching solutions for instruction or education that would otherwise be delivered face-to-face or as blended or hybrid courses and that will return to that format once the crisis or emergency has abated (Hodges et al 2020; Trust & Whalen. 2020).

Not only did the sudden outbreak of the pandemic catch educators off guard in making a rapid transition to online teaching for which many had little to no training in online instruction, but the situation is even further exacerbated by the fact that many STEM teachers are teaching out of field, due to a serious shortage of STEM teachers. Such teachers were already struggling with an insufficient background in STEM and were in serious need of upskilling in STEM, and the number of out-of-field STEM teachers is likely to increase as teacher attrition has escalated since the onset of the pandemic (Luft et al, 2020; Hobbs & Törner, 2019).

Vision

The NASA Digital Badging System operated by the NASA STEM Engagement and Educator Professional Development Collaborative (EPDC), is a free educational resource that provides an enhanced STEM learning journey for educators and students. Teachers at all different levels (pre-service, K-12, university faculty, and informal educators) can utilize the badging system for their own professional development or to supplement their STEM instruction by providing enriched learning opportunities to their students through the integration of NASA Digital Badges. Teacher educators can introduce this resource to their preservice students to not only enhance their STEM background knowledge but also to introduce them to an online learning resource that they can later use with students in either an online or face-to-face learning environment.

A “digital badge” is a micro-credential or certification in a specific topic area. The NASA STEM EPDC Digital Badging System allows educators and students to select from a wide variety of STEM topics, engage in learning opportunities, demonstrate mastery of the topic and receive a badge of accomplishment for work that can be shared with others of their choosing. Digital badges are aligned to Next Generation Science Standards (2013) and the Engineering Processes and Practices (National Research Council, 2012) and typically consist of 4-6 activities per badge. Progress in skill attainment is monitored and the system keeps an ongoing record of the assessments and badges completed. Further, educators can convert their badge credit into Continuing Education Units (CEUs), allowing them to receive professional recognition from their employers and state teacher licensure boards.

Digital Badging System for Educators

The NASA STEM EPDC Digital Badging System offers more than 60 badges in the following eight categories:

- Earth & Space
- Engineering & Technology
- Life Science
- Mathematics
- Next Gen STEM
- Physical Science
- STEM Instructional Practices
- NASA Strategic Themes

Badges are asynchronous and thus can be worked on when it is the most convenient for the educator. Each badge entails approximately 3-5 hours of instruction and educators can complete badges at their own pace. Badge submissions are reviewed by a NASA EPDC

Education Specialist who will approve credit for the badge completion or will provide the educator with feedback on needed revisions. New badges are developed and published on a regular basis. A complete badge list and badge descriptions may be found at www.txstate-epdc.net/digital-badging and educators are encouraged to explore the many available badge options.

The NASA Strategic Theme badges feature special topics that are currently being highlighted by NASA. Badges in the STEM Instructional Practices categories are applicable to teachers in all STEM subject areas and feature general STEM teaching strategies, with a special emphasis on culturally responsive STEM education, as illustrated by the following two badges.

Digital badge on "Preparing to be Culturally Responsive." This badge offers participants to carefully examine the teaching of STEM content, and how instructional practices influence the nature by which STEM is learned. Through engaging in the required badge content activities, it is expected that participants will enhance and possibly transform their beliefs and/or practices about STEM, creating new inroads into becoming more critically conscious about STEM and STEM education.

Digital badge on "Practicing Equity in STEM Education." This badge examines the barriers in STEM Education for students from underrepresented groups and discusses how diversity is a primary goal for NASA. The contributions of women, notably Katherine Johnson, is spotlighted and demonstrates how to make STEM more relevant to diverse students. The principles of Culturally Responsive Engagement and Teaching are integrated into lessons from NASA's Modern Figures Toolkit, which was inspired by "human computers" portrayed in the popular movie *Hidden Figures*.

Digital Badging System for Students

Teachers can introduce authentic NASA content to their students by utilizing the EPDC Digital Badging for Students. Teachers are encouraged to first complete a brief 1-hour badge titled "STEM Instructional Practices - Using Badges with Students" and then to explore the student badges which include:

- Aeronaut–X (Experimental Planes)
- Red Planet/Green Thumb
- Preparing for Life on the Red Planet
- Exploring and Living on the Moon
- We Are the Artemis Generation: Phases of the Moon
- Moon to Mars–We Go as the Artemis Generation
- Orbital Systems
- NASA Commercial Crew Program–Next Gen STEM

Through the Badging System for Students, teachers can add their students to a "community" that will only display the badges selected by the teacher. Students will receive an email invitation to join the group and the teacher will be the student work reviewer. When the teacher has determined that the student has successfully completed all steps in the badge, the student will earn the badge and can download the certificate of badge completion.

Implementation

The NASA Digital Badging System has been widely utilized by educators of all types as well as K-12 and university students. Since its inception in 2016, educators and students have earned 3,471 NASA STEM EPDC digital badges representing approximately 23,517 hours of

instructional credit (reference EPDC Quarterly Report). The following examples are offered to illustrate the various contexts and uses that have resulted in substantive STEM learning that incorporates specific NASA applications using NASA content and educational resources.

Digital Badging in Pre-Service Education Programs

Example 1. Professor Smith teaches a curriculum and instruction course for teacher candidates preparing to be elementary teachers. In this course, students review the state curriculum standards and Professor Smith has developed a course assignment utilizing the state STEM standards and the NASA Digital Badging System. Students are to select a specific grade level and then to review the badges in the Digital Badging System for Students to identify a badge that aligns with specific STEM standards for the grade level they have selected. Students are then asked to complete the student badge and will receive a certificate once the badge has been successfully completed. Students will then prepare a reflection that identifies the specific STEM standards that align with the badge they selected, reflect upon the badge completion experience, and discuss how they might incorporate the use of digital badges with their future students. Students then submit their certificate and the reflection to the course online Learning Management System, for review by Professor Smith.

Example 2. Professor Jones teaches a STEM pedagogy class for teacher candidates who are preparing to be secondary STEM teachers. In the course, students are introduced to the possibility that they may at some point in their careers need to teach in an online learning environment, as was the case recently for teachers who were asked to teach remotely during the COVID pandemic. The NASA Digital Badging System was introduced both as a professional development resource for educators and as an online learning opportunity for students who are engaged in remote learning. Professor Jones demonstrated how to explore the various badges and

students were given the assignment to select and complete one of the educator badges that would be beneficial to their specific content area, and to complete the educator badge titled "Using Digital Badges with Students." Teacher candidates were given a deadline to submit their two digital badging certificates and after this assignment was completed, Professor Jones devoted a class period to the topic of "online-STEM instruction." During class discussions, Professor Jones solicited input from the students about their experiences in the NASA Digital Badging System and their thoughts on how they might use this tool with their future students. Students were then given the option of completing additional badges for extra credit.

Digital Badging as Professional Development for In-Service Educators

Example 3. Mr. Sanders is a middle school science teacher is a participant in a state level Space Education Ambassadors Program. Participants in the program attend 1-2 webinars per month, complete five NASA digital badges from the Next Gen STEM badge series and agree to conduct one professional development workshop for colleagues and sponsor one STEM Engagement opportunity for students. Badges are focused on Aeronaut-X, the Commercial Crew Program, and the Moon to Mars Artemis missions. Educators in the program who successfully complete the requirements receive a $1,200 stipend and get to participate in a day-long field trip to a NASA Center in which their travel expenses and substitute teacher costs are covered by the program.

Digital Badges as a Student Learning Experience

Example 4. Ms. Anderson, is the computer science teacher and department chair at an all-girls school serving grades 6-12. In conjunction with the "Space Tech" program developed by Ms. Anderson, NASA EPDC Digital Badges were added as a key element in the program. A tailored series of Python programming exercises were taught in parallel with units from the

digital badging curriculum, which offered background insight into space technology based problem-solving environments. This program was delivered concurrently with the Computer Science curriculum in response to rapidly growing career prospects in space tech as students learned about Space X and the launch of the NASA James Webb Space Telescope. The students were involved in asynchronous STEM learning that led to earning digital badges and learning about the exciting work of NASA, while being provided with a strong academic foundation for pursuing future academic programs and career exploration in the space tech industry.

Lessons Learned

In its six years of operation, several lessons have been learned about the utility and use of the NASA Digital Badging System. The major lesson is that while a few people are motivated to independently seek out learning opportunities for personal and professional growth, most learners function better as a part of a group and in a structured experience. In each of the four examples provided, badge earners were a part of a group and were working to complete an assignment for credit. The Digital Badging resource is there for use by anyone at any time, but it is most heavily used by educators who have structured a learning experience that incorporates the completion of one or more digital badges as a part of that experience. A second lesson that has been learned is that when teachers first learn about the Digital Badging System, their first inclination is that they are more interested in having their students complete badges than they are in completing badges themselves for professional development. Teachers are very busy, so this initial reaction is very understandable, but our experience has been that when teachers complete the educator badges, they find the content very useful and often then begin to utilize this content in their own teaching. The EPDC approach that has worked best is to start where the educator wants to start and to introduce them to additional learning opportunities along the way. Once

educators are familiar with and comfortable with the learning platform, they can think of many ways to integrate the rich content into the learning experiences they are designing.

Conclusion

It is critically important that students at all levels be provided with engaging STEM learning experiences that will motivate them to pursue further STEM opportunities and possible career options. Teachers need preparation and educational resources to enable them to deliver this type of STEM instruction to students, and teacher educators need to provide prospective teachers with rich STEM background knowledge and pedagogical skills that will promote student success in STEM.

The use of technology and online learning tools has always been important in STEM teaching, but the recent pandemic has clearly demonstrated that teachers need to be prepared to quickly shift to pre-planned online learning. It has also become clear that online learning tools are most effective when they are integrated with a cohesive curriculum rather than used in isolation as is sometimes the case with emergency remote teaching. The NASA Digital Badging System is a free resource that can be utilized by educators at all levels to bring rich STEM content with specific NASA applications to students and provides a convenient way for teachers to engage with cutting edge STEM content and to earn professional development credit. When utilized by teacher educators, the NASA Digital Badging System can not only provide prospective teachers with dynamic STEM content knowledge but can also introduce them to an online learning resource that they can utilize with their future students.

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