Micro-Credentials for Research and Service Learning to Enhance the Engineering Student Experience

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Many students are looking for flexible ways to achieve their educational goals and sometimes to expand their skills and knowledge beyond the traditional classroom. A large number of students pursue undergraduate research, service-learning, and even study abroad experiences, receiving academic credit documented on a transcript. Students value these experiences even though their credit hours during these semesters are higher than their peers. University leadership sees value in micro-credential programs in terms of revenue and professional development opportunities for students, staff, faculty, and alumni. Micro-credentials and digital badges have gained popularity in recent years as ways for higher education institutions to provide competencies, knowledge, and skills quickly and effectively, especially when the needs of the workforce change faster than the curriculum. However, a recent development at the institution requires students who exceed a certain credit hour ceiling to pay for the additional credit hours. Rather than add a financial burden and deter students from these high impact experiences, badges and micro-credentials became a way to document and reward these high achievers. Implementing a micro-credential program at a large university summons discussion on resources, definitions, design, best practices, delivery, support, and evaluation of the micro-credentials from various stakeholders. This paper describes the challenges encountered in the educational framework, support, and student deliverables for implementing and designing digital badges within the College of Engineering. The badges allow students to take ownership of their learning at various levels and badge descriptions are more descriptive than generic transcript descriptions. These badges are a faculty-validated means of recognizing the students' additional skills and can be used as an additional assessment tool with feedback from student surveys and administrators, providing opportunities for initial evaluation as well as continuous improvement of badges.

Background

"Micro-credential" is a broad and vague term that recognizes a distinct skill or accomplishment. However, a micro-credential can describe a variety of formats to include certificates, nanodegrees, and digital badges [1]. Similarly, the term alternative credentialing has been used widely as an important way to recognize learning and skill attainment that occurs in a wide variety of environments. They are defined as "competencies, skills, and learning outcomes derived from assessment-based, non-degree activities and align to specific, timely needs in the workforce" [2]. They are offered through higher education institutions, industry, and many non-academic affiliated vendors.

One form of micro-credentials is a digital badge. Digital badges have become increasingly popular and present in higher education. A digital badge's metadata provides context and contains basic information about skills earned and accomplishments [3]. Their popularity can be attributed to cost, availability, and perceived value. Conventional college and university degrees require a much higher time commitment and cost, so digital badges are not viewed as a substitute for a degree. However, they can act as documentation of skill and knowledge proficiency [4].

For employers, digital badges help them recognize and discern skills in potential and current employees. Traditional grades and diplomas verify a baseline knowledge but may miss skills sought in industry. There are many digital badges centered on professional skills such as: critical thinking, communication, collaboration, and resilience [5].

From the student perspective, digital badges provide additional accessibility and motivation to gain knowledge and proficiencies from a variety of sources. With fixed curricula, especially in rigorous STEM programs, opportunities to take elective courses are limited, but digital badges offer exciting opportunities beyond their traditional program of study [6]. Digital badges split learning into smaller units and are certified separately, allowing the student flexibility in when and how far to further their skills.

In addition to motivating learner engagement and achievement, digital badges can also be used as a means of:

1. Supporting alternative forms of assessment, differing from standardized tests as the dominant form of knowledge assessment
2. Recognizing and credentialing learning, meeting the increasing workplace demands for evolving skills and competencies
3. Mapping learning pathways, scaffolding student exploration through a curriculum
4. Supporting self-reflection and planning, tracking what was learned and insight to next steps [7].

Need

Due to the micro-credential term used broadly and often inconsistently throughout higher education and by many non-institutional providers of professional development programming, the term may leave one confused. Students, employers, and other educational providers may wonder if it refers to the educational experience or the evidence of achievement earned for the successful completion of a learning experience. This institution has steered away from using the term micro-credential as an official descriptor of a learning experience or marker of achievement. In fact, all digital credentials take the form of a digital badge at Penn State University. They may have different names and levels, but the technology platforms (e.g. Credly, Canvas Catalog, etc.) adopted at the institution refer to all digital credentials as digital badges.

Digital badges have been offered at Penn State's College of Engineering since 2019. Before Fall 2023 students experienced a fixed rate for full time (12 or more hours) tuition. There was not an upper limit, but students needed exceptions if enrolled in more than 21 hours. Beginning Fall 2023, students registering for more than 19 hours in a semester were charged for each additional credit. This was not a problem for those who planned for the increased hours such as double majors and those that wanted to graduate sooner rather than return for a few courses. However, many students who were engaged in high impact practices (internships, co-ops) and other out of

the classroom activities (undergraduate research, service learning) were in a dilemma. Registering for courses to show engagement in these activities on their transcripts while attending their normal classes soon triggered the extra tuition surcharge. They could: 1) pay to earn the extra credit as a volunteer in undergraduate research or in service learning; 2) continue to volunteer for these activities and not register for the course, losing the record of experience; 3) discontinue the high impact practice.

Students motivated to learn beyond the traditional classroom now had financial limitations, so the college explored ways to recognize student achievement through digital badging. Students who faced the financial burden of participating in these activities without documented effort and reward (transcript) now had other means to acknowledge their endeavors.

Structure

The College of Engineering recently developed guidelines for digital badge development, terminology, and administration. The learning experiences digital badges are categorized into one of the following areas:

1. **College of Engineering Certified Micro-credentials -** learning experiences that issue digital badges requiring increased quality assurance and academic review at the College level. In many cases these credentials will be offered to an external audience for a fee and will offer working professionals or current students a substantive learning experience.
2. **College of Engineering Badged Learning -** learning experiences that issue digital badges with quality controls managed at the faculty and department level. In many instances, these credentials will be offered to current students who can share achievements in curricular and co-curricular learning experiences.
3. **Other Digital Badges -** digital badges issued internally for purposes such as recognition, motivation, and gamification etc. These badges will not include the university logo. Currently, this category of badges is not being created by the college, but future interest and university-wide tools may permit this kind of badging.

With a clear need to keep students engaged beyond the classroom and a digital badging structure in place, many units in the college have implemented or are developing new digital badges. Some of these efforts are discussed in the following sections.

Undergraduate Research

The Center for Engineering Outreach & Inclusion supports students and mentors involved in research. The Micro-credentials for Undergraduate Research are a series of digital badges which students can earn while they engage in a connected research experience. The badges allow students and mentors to have a connected and engaged research experience that utilizes best practices for undergraduate research, facilitating effective conversations and value add pieces for the student and mentor.

The College of Engineering has long facilitated connected research experiences for undergraduate students. The Student Research office offers a robust student research support network to facilitate research exploration in undergraduate students and their structured programming for students in engaged research experiences layers best practices into structured research programming. Current practices have students participating in research through a variety of options, including engaged scholarship programming, research for academic credit, or students can earn wages though research as a work experience.

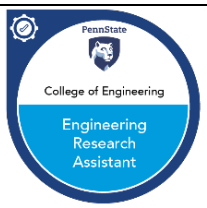
Many research studies extol the benefits to undergraduate students who participate in a connected research experience, including better conceptualization of course material in the classroom, determining areas of interest and exploring career paths, improved communication skills and discovering a passion for research leading to graduate school [8-11]. Engagement in collaborative research and multi-disciplinary networking through such early encounters may positively affect retention and time to degree [12]. Furthermore, several studies show the significant role undergraduate research plays in broadening the diversity of the STEM workforce [11, 13-15].

At Penn State, students are not permitted to be in a research experience on a volunteer basis. The understanding is that students should earn something beyond experience through their research engagement. Volunteering students would add a vulnerability to faculty who could not properly document the mentorship and service they added to the student in a quantifiable manner. Limited resources meant that paid opportunities were not always available for the student and an enrollment credit charge meant that students with a large credit load would have to pay to gain research experience. Finally, the Student Research office had best practices to offer students engaged in research but limited capacity with how many students could utilize their resources.

Research micro-credentials for undergraduate researchers fills multiple gaps and allows all students to have an engaged research experience that follows known best practices for students. For students wishing to enter a research group without undergraduate research funding or research credit hour availability, students can enroll in a no cost micro-credential to meet university requirements and research accountability. For faculty mentoring an undergraduate, they have access to best practices in undergraduate research and support in onboarding and mentoring their students through the micro-credential network. Additionally, the micro-credential program is structured so that students in any means of engagement with research can also participate in the programs. This allows all students to access the best practices and resources available through the Student Research office and the Center for Engineering Outreach and Inclusion. Structured in four digital badges, the Undergraduate Research micro-credentials connect students to structured mentoring practices through research contract discussions and connected reflection questions. Students additionally create deliverables that add value to their experience and the research groups they serve with activities such as documenting a standard operating procedure for the research group, building a literature review, and presenting their

findings at connected conferences for the student and/or their discipline. Table 1 displays the four levels of the badges.

Table 1: Undergraduate Research Badges

Level	Level 1	Level 2	Level 3	Level 4
Image				
Badge Name	Undergraduate Research Experience	Undergraduate Research Foundations	Engineering Research Assistant	Engineering Undergraduate Researcher
Duration	1 semester	1 semester	1 semester	2 semesters
Credly Level	Foundational	Intermediate	Intermediate	Advanced
Skill Tags	Communication, Goal Setting, Research, Safety, Ethics	Communication, Goal Setting, Research, Procedure Documentation	Communication, Goal Setting, Research, Literature Review	Communication, Goal Setting, Research, Data Analysis, Presentation
Experience -specific criteria	Participate in research; Complete research contract; Complete midpoint reflection; Complete endpoint reflection	Participate in research; Set new goals for participation in research contract; Produce standard operating procedure; Complete midpoint reflection; Complete endpoint reflection	Participate in research; Set new goals for participation in research contract; Complete midpoint reflection; Conduct literature review; Complete endpoint reflection	Participate in research; Set new goals for participation in research contract; Conduct Data Analysis; Complete midpoint reflection; Create presentation with conference audience in mind; Complete endpoint reflection
Additional Criteria	Complete online safety module, Complete online ethics module	Prior completion of level 1 badge.	Prior completion of level 1 and level 2 badges	Prior completion of level 1, 2 and 3 badges.
Course available	SP24	SU24	SU24	FA24

With the initial launch of the Level 1 Undergraduate Research Experience Badge in Spring 2024, approximately 17 students are completing the requirements for the credential. Feedback from the students and faculty will improve the experience and administration of the program for other students.

Service Learning – Global Fellows

Badging has been incorporated into the Global Engineering Fellows Program [16], a service program that the College of Engineering established in 2016 to enhance visibility and promotion of study abroad for engineering students. Fellows are selected from engineering students who have participated in a study, research, or internship experience abroad. Prior to earning status as a Fellows, students must enroll in a credit bearing course where they learn and begin to apply the skills required to be successful as Global Engineering Fellows. Participants in the program connect with their peers and continue to build on their global competencies and cultural intelligence. Among the course topics, Fellows learn how to articulate the value of their acquired abilities to potential employers, develop presentations about their experiences, and are trained to serve as peer advisors.

After having completed the course, Fellows are eligible to begin service. Each semester, the group collectively staffs nearly 100 events, speaks in front of hundreds of students, and holds an average of 30 peer advising hours weekly. Furthermore, Fellows engage in required global professional development and help integrate international exchange students into the College of Engineering to achieve the program's mission: "Empowers globally minded engineering students through targeted professional development that integrates international perspectives, cultural intelligence, and the ability to deliver a compelling message. We generate global momentum as we inspire others to enrich themselves and the world through meaningful international experiences" [16].

After matriculating into the program, Fellows who meet the service requirements described above earn a Global Engineering Fellows badge. Since awarding badges began in 2020, 67 have been issued and it is expected that approximately 20 more will be earned in 2024. While students previously earned a grade for skill building in the required gateway course, this credential provides Fellows with an opportunity to be recognized for their contributions as active participants in the program. The badge may function as external motivation to remain engaged. Additionally, Fellows have the capability to display the badges on their LinkedIn profiles, where peers, employers, college alumni, and a network of Global Engineering Fellow alumni are made aware of the achievement. Promoting the badge on this professional networking platform can enhance career opportunities, program visibility, and further the goal of generating student interest in global opportunities.

Below is a summary of student comments on the value of the Global Engineering Fellows Program:

- Through the Fellows Program I've been able to build confidence in giving presentations by being able to present on something that I am so passionate about. I see that confidence bleed into other presentations and other areas.
- I had a phenomenal experience [abroad], and I feel like there's a lack of awareness that you can go abroad as an engineer, so I just wanted to help spread that message.
- [At the University] it can be difficult sometimes to reach out and connect with people who maybe you wouldn't normally because they have different experiences from you…different interests. And with the Fellow programs… it gives me a great opportunity to connect with people who aren't from the US and are here on exchange and become friends with them and learn from their experiences.
- This program came up so many times in my interview process when they ask you the questions of "how have you been a leader? What have you learned?" I always was able to relate it back to Global Engineering Fellows, how this propelled me, and how I deal with others or how I manage others…It's helped me in getting a job.

Given the success of the Global Engineering Fellows badging initiative, there may be a possibility to build on the momentum created through the credential. Veteran Fellows currently serve as mentors to new members, completing additional requirements and training outside of a credit bearing structure. Thus, it may be useful to establish two tiers of badging, Level 1 for initial requirements, with the possibility for a Level 2 credential should Fellows serve as mentors. See Table 2.

Table 2: Global Engineering Fellow Badges

Level	Level 1 Badge Link	Level 2 Badge Link
Image		*NA (under development)*
Badge Name	Global Engineering Fellow	Global Engineering Fellow Mentor
Duration	2 semesters	3-4 semesters minimum
Credly Level	Advanced	Advanced
Skill Tags	Cultural Intelligence (CQ); Global Competencies; Global Skillset; International Experience; Study Abroad	Mentorship; Communication; Goal Setting; Service

Experience-specific criteria	International engagement in study, research or an internship abroad; Completion of the Global Engineering Fellows academic course, designed to build on international experiences, enhance cultural intelligence and further global professional development; Completion of a presentation certification process through the Center for Global Engineering Engagement; Service to the College of Engineering as a Global Engineering Fellow by staffing events, making presentations, and serving as a peer advisor on global opportunities.	Mentorship; Service; Additional criteria under development
Course available	FA23	TBD

Service Learning – Peer Advisors

The Engineering Peer Advising Leaders (EPALs) program at Penn State provides College of Engineering pre-major students access for guidance on routine questions like how to navigate the student records and course systems or what it is like to be in a particular major from upper division peers who receive rigorous training and oversight by a professional academic adviser. [17]. In addition to providing benefit to the pre-major students, these EPALs grow their leadership and communication skills through a variety of professional development activities.

EPALs have reported a wide range of positive impacts from preparation and participation as a peer adviser. Here are just a few examples of this feedback.

- "I was able to gather abstract problem solving from helping a student."
- "I went for an interview at XXXX company; the interviewer was impressed because I referred to Clifton strength inventory which I did as part of the training I received as a LEAD EPAL."

Credentials documenting this training and development for each EPAL has historically come in the form of seminar course credit. But as this paper has laid out, this practice is now proving to be problematic when these additional professional development/service credits are taking them beyond the 19-credit limit, causing them to have to pay additional tuition.

A micro-credential had not yet been developed for the EPAL program. As a result, several of the Fall 2023 students who would have incurred the tuition surcharge by adding the EPAL training course, simply didn't sign up for the credits. They still participated in the activities in order to

gain robust professional development and be properly prepared to serve as an EPAL, but they currently do not have any type of official credential to show for that work. Development of a micro-credential as an alternative means of recognizing this work is underway. At the writing of this paper, this badge is in the very early stages of development with initial implementation intended for the incoming Fall 2024 EPAL team. In addition to addressing the problematic surcharge, development of this badge will address the desire past EPALs have expressed for some type of professional credential beyond course credit to recognize this important professional development and service to the college. Students for whom enrollment in class credit is problematic will be able to earn the Level 1 badge while those who do not have issues with having the course added to their schedule will continue to receive course credit. In the future, we anticipate the creation of additional badges beyond Level 1 to recognize the efforts and accomplishments of EPALs who continue this service beyond the first year as well as those who go on to serve in a leadership role in the program.

Table 3 provides a draft overview of the elements that are currently anticipated to be included in this new series of badges, created with different levels associated with the increased professional development peer advisers achieve as they progress in their service to this program.

Table 3: Proposed EPAL Badges

Level	Level 1 Badge Link	Level 2 Badge Link	Level 3 Badge Link
Image	*NA (under development)*	*NA (under development)*	*NA (under development)*
Badge Name	Engineering Peer Advising Leader (EPAL)	2nd Year EPAL	Lead EPAL
Duration	2 semesters	3-4 semesters	4 semesters
Credly Level	Intermediate	Advanced	Advanced
Skill Tags	Communication, leadership, time-management, active listening, self-awareness, goal setting.	Communication, leadership, time-management, active listening, self-awareness, goal setting, mentoring	Communication, leadership, time-management, active listening, self-awareness, goal setting, mentoring, scheduling, and planning
Experience-specific criteria	Complete training modules; Complete six-hour synchronous training; Participate in training to develop, communication, active listening, leadership & soft skills; Observe EPAL sessions Serve as an EPAL by volunteering to be a peer	Mentor new peer advisers. Serve as an EPAL for at least two semesters.	Mentor first and second year EPALs, additional responsibilities (planning events, scheduling, serving as points of contact for projects).

	adviser, staffing events and making classroom presentations.		
Additional Criteria	Complete BUILD Training Level 1 from the LRN network.	Prior completion of EPALs Level 1 badge; Complete Build Training Level 2 from LRN	Prior completion of EPALs Level 1 and Level 2 badges; Complete Build Training Level 3 from LRN.
Course available	FA24	TBD	TBD

Discussion

The digital badges discussed in the previous sections have been works in progress for one to two years to document student's acquired skills and achievements. Their fruition allows students to experience these enriching opportunities without incurring costs from adding additional credit hours as in the past. Each of the digital badges are versatile as they represent achievement in different educational experiences. At the same time, versatility is not without quality control and oversight.

The skills developed and employed are many of the same ones sought by future employers. Employers still desire technical competence, but the acquisition of knowledge is shifting towards knowledge application along with more cross-disciplinarity and collaborative work [18]. The National Association of Colleges and Employers (NACE) in their 2022 report, Competencies for a Career-Ready Workforce, lists eight competencies for success in the workplace and life-long career management along with many sample behaviors associated with the competency [19]. Table 4 shows the badges mapped to the NACE Career Competencies and some of the associated sample behaviors.

Table 4: Badge Mapping to NACE Competencies and Sample Behaviors

Competency	Sample Behaviors	Badge
Career and Self-Development	1. Professionally advocate for oneself and others. 2. Display curiosity; seek out opportunities to learn. 3. Seek and embrace development opportunities.	Research Global
Communication	1. Frame communication with respect to diversity of learning styles, varied individual communication abilities, and cultural differences. 2. Promptly inform relevant others when needing guidance with assigned tasks.	Research Advising
Critical Thinking	1. Gather and analyze information from a diverse set of sources and Individuals.	Research Global Advising

	2. Effectively communicate actions and rationale, recognizing the diverse perspectives and lived experiences of stakeholders.	
Equity and Inclusion	1. Solicit and use feedback from multiple cultural perspectives. 2. Seek global cross-cultural interactions and experiences that enhance one's understanding.	Global
Leadership	1. Motivate and inspire others by encouraging them and by building mutual trust. 3. Plan, initiate, manage, complete, and evaluate projects.	Research Global Advising
Professionalism	1. Act equitably with integrity and accountability to self, others, and the organization. 2. Prioritize and complete tasks to accomplish organizational goals.	Research Global Advising
Teamwork	1. Be accountable for individual and team responsibilities. 2. Collaborate with others to achieve common goals	Research Global Advising
Technology	1. Identify appropriate technology. 2. Quickly adapt to new or unfamiliar technologies.	Research

As employers seek specific skillsets beyond the standard higher education curriculum, students need to provide evidence that they have the knowledge and skills and can add value to the organization. Like educational products provided by many organizations, quality and standards are one factor when students invest time to acquire them. Students can gain these additional skills through digital badges to validate these experiences. Additionally, the badges are voluntary and easily adaptable to the learners' location and pace. Mapping the criteria and achievements of the badges to skills and competencies sought by employers make them easier to interpret. Completion of a formal degree is usually certified by a transcript that contains titles and coursework, whereas the digital badge expresses outcomes and skills.

Conclusion

Colleges and universities must relook at the focus on degree achievement and include new learner centered interests through skill attainment. Digital badges provide one way for students to document their educational currency in a rapidly changing environment. A digital badge represents a range of achievements gained by a learner in both formal and informal learning experiences. The badge displays the learners' achievements with metadata, which is visible information that describes what the learners can do after earning a badge, what they had to do to earn it, and why employers or others viewing the badge should care about it. Digital badges are not the final answer on filling knowledge gaps in a rapidly changing workforce, but with deliberate development and implementation, they can enhance and complement quality higher education structures.

Future work includes continuing work on the digital badges described in this paper as well as seeking other opportunities to expand the college's digital badge portfolio. Feedback from recent industry and professional advisory boards will refine and prioritize efforts in digital badging. The demands on higher education are continually evolving, and industry advisory boards are in the best position to articulate their needs and interests. Adding digital badges to an institution's educational offerings makes sense to fulfill these needs as they provide additional value to existing students and have the opportunity to help employers fill existing skills gaps.

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