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Enhancing Student Engagement and Skillsets towards Transportation Careers Using Digital Badge Program: A Case Study

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Abstract

Changing technologies and job market dynamics have led many jobs in the transportation industry to require a higher degree of technical skills, a more diverse base of disciplinary perspectives, and adaptability. Targeted training of students in these skills and support networks for student success have been found to be critical for students, particularly those from underrepresented minority (URM) groups, who face additional constraints due to various competing goals vying for their energy, time, and attention. The ASETTS (Advancing STEM Education Through Transportation Studies) program is a digital badge program created to prepare undergraduate students with a variety of skills needed to be successful in the transportation workforce. The program uses a stackable-units framework through which students can earn digital badges (i.e., micro-credentials) that are awarded in the form of certificates and is designed to incentivize student participation in transportation career development activities. This case study addresses the question whether digital badge programs are effective in addressing the stated needs of preparing undergraduate students for a highly versatile and multi-dimensional transportation workforce within the constraints of limited time and motivation for the involved students**.** Over the course of last year, the program has recruited 100+ students across an array of disciplines who have demonstrated engagement in activities for primarily three badges: Transportation Awareness and Engagement, Transportation Research, and Transportation Core Skills. The program has resulted in an increase in participation in various engagement, research, and experiential learning activities. Through qualitative and quantitative feedback, we observe that digital badges facilitate the engagement of students and help prepare them for relevant skills pertaining to life/career, innovation, technology, research, and core subject matter.

1 Background

Over the years, emerging technologies in transportation have resulted in new modes of transporting people and goods such as ridesharing, unmanned aerial vehicles, smart city sensor technology, and connected and autonomous vehicles. Due to such advances in technology, many jobs in the transportation industry require a high degree of technical skills and often necessitate degrees in STEM fields such as civil, mechanical, or electrical engineering or transportation/supply chain programs. Due to its interdisciplinary nature, jobs in transportation create a high barrier of entry for students who are not trained in the required computational, technical, and key non-technical skills [*1*]. Additionally, training in transportation must align with the evolving needs of society such as the focus on sustainability (including economic, environmental, and equity issues).

The recruitment and retention of minorities in the transportation industry have been a continuous challenge [*2, 3*]. Research has shown that approximately 65% of students who set out to pursue a STEM degree do not complete their degree within 6 years [*4,5*]. The outlook tends to be bleaker for minorities, where Black students are twice as likely to leave the STEM major relative to White students [*6*]. Several factors influence the lack of minority students' success in STEM including disparities in affordability, reduced access to advanced placement courses, and the presence of "inferior cognitive and math ability stereotype" threats [*6*]. Thereby programs that address these critical factors by providing experiential learning opportunities (e.g., case studies, competitions, undergraduate research experiences) for students and support (e.g., mentors, scholarships, community engagement) in STEM disciplines have had positive impacts on students' success [*4*].

Another component critical to the preparation of undergraduate students with competitive skillsets needed for success in the STEM workforce is motivation. Students' motivation generates, directs, and sustains what they do to learn [*7, 8*]. However, undergraduate students have various competing goals vying for their energy, time, and attention. Students must choose between a multitude of certificate programs and extracurricular activities while often working a job to support their families and maintain their lifestyle. For example, in 2018 the U.S. Department of Commerce reported that 43% of full-time undergraduates and 80% of part-time undergraduates from African American backgrounds were employed while in school [*9*]. Given these trends, new and dynamic programs are needed to provide students with the skills required to be competitive in a highly versatile and multi-dimensional transportation workforce and to help underrepresented minority students remain motivated so they can transition successfully into transportation jobs.

This article presents the findings from the ongoing stackable units digital badge program at North Carolina Agricultural and Technical (NCA&T) State University designed to address the needs specified above by providing students with the skills required to be competitive in a highly versatile and multi-dimensional transportation workforce. The digital badge program, called Advancing STEM Education Through Transportation Studies (ASETTS), is a micro-credentialling program that has been active since September 2021. The overarching *goal of the ASETTS program is to advance STEM education through activities designed to increase the number of highly skilled undergraduate students entering the transportation workforce at NCA&T*. This goal is achieved broadly by augmenting the curriculum and learning mechanisms used both inside and outside of the classrooms and by creating a transportation community for university students, faculty, and alumni in STEM-related disciplines. The ASETTS activities connect students to researchers, practitioners, and alumni from STEM-related backgrounds who are currently working in the transportation field. The program has five specific objectives in the progression toward the goal.

1. *Create* a stackable-units digital badge program enabling undergraduate students to increase their skill sets along various dimensions such as life/career skills, innovation skills, technology skills, and core subject matter skills.
2. *Update* existing and associated courses with skillsets needed in the transportation workforce, specifically those found in the P21 and experiential learning frameworks.

3. *Establish* a professional-to-student and student-to-student mentorship program to provide a support network for students participating in the program.
4. *Increase* the number of undergraduates participating in transportation research experiences and scholarships.
5. *Increase* the number of students participating in activities that will expose them to career opportunities in transportation.

Figure 1 shows an overview of the stackable units digital badge program (with five badges - Core Skills, Research, Community, Awareness and Engagement, and Leadership badges, and one starting milestone on Career Exploration and Professional Development) and how the project objectives contribute towards strengthening the components of this program. In this article, we evaluate the following research question through a case study: "***Are digital badge programs effective in addressing the stated needs of preparing undergraduate students for a highly versatile and multi-dimensional transportation workforce within the constraints of limited time and motivation for the involved students?***" We also evaluate factors that result in success for such badge programs and how can future programs benefit from this case study.

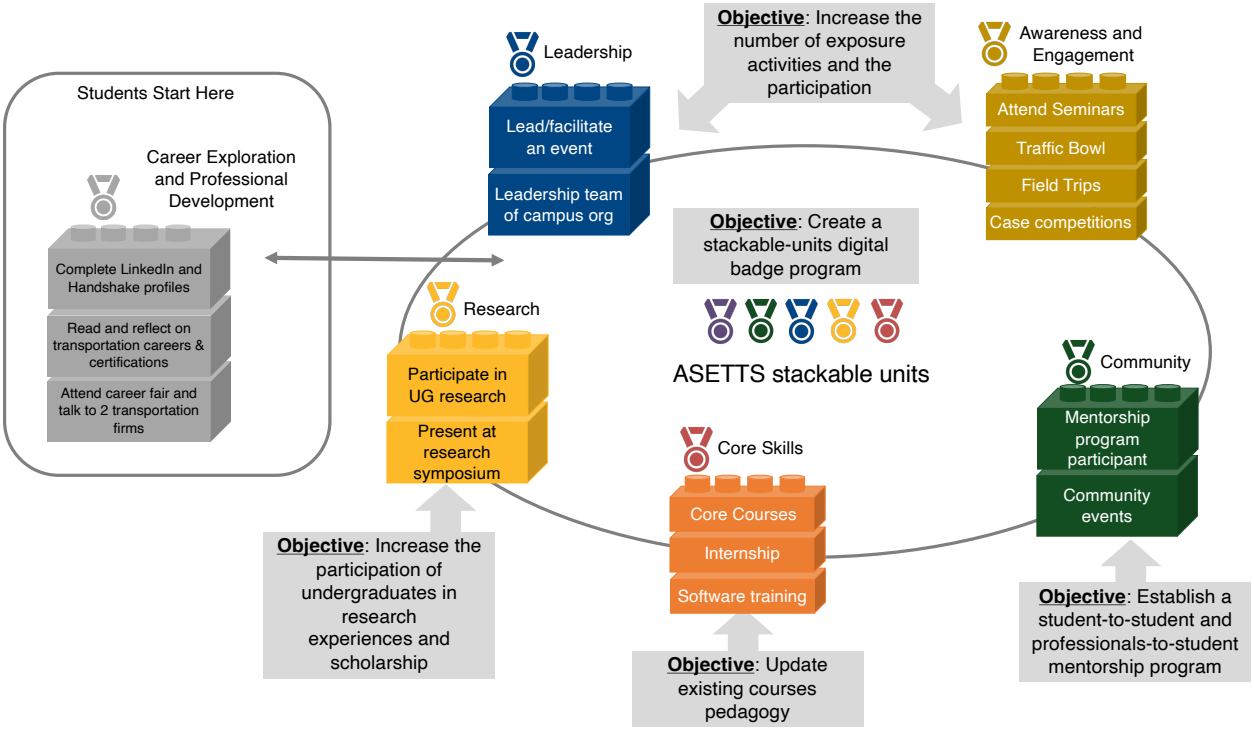

Figure 1 Digital badge program with stackable units

The rest of the article is organized as follows: Section 2 discusses how the program builds on the existing literature on enhancing student engagement and motivation; Section 3 presents the design of the badge program, the interface used to gamify the platform, and the initiatives used to recruit and retain students within the program; Section 4 presents the findings from our case study, and Section 5 concludes the article and discuss the ongoing/future work.

2 Literature Review

Engineering and technology education is often criticized for producing students without some of the most critical skills required to succeed in the workforce. While technical skills are essential and must be among the primary outcomes of any STEM education program, they are not the sole skills needed by STEM graduates. Upon graduation, STEM students should be equipped with the skills necessary to communicate both orally and in written form, work in and lead diverse teams, think creatively and critically, and adapt to the ever-changing work environment. These transferrable skills are commonly referred to as soft skills [*10-12*]. Transferrable skills were deemed vital enough to the STEM community that they were integrated into the ABET accreditation criteria at the end of the 20th century [*13*].

The ASETTS program builds upon the structure provided by the P21 and experiential learning frameworks in the literature.

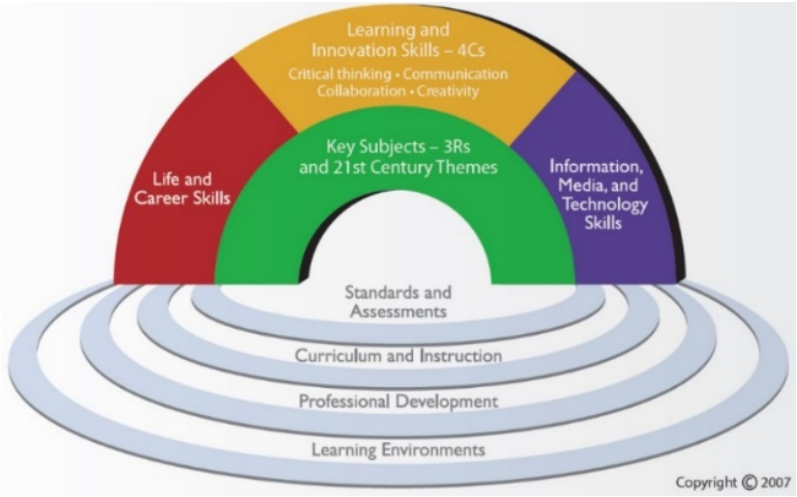

Figure 2: 21st Century Learning Framework [*14*]

Figure 2 graphically depicts the elements of the P21 Framework including the "21st-century student outcomes" represented by the rainbow. Note, while the illustration shows each distinct element independently, they are interconnected components and work together to enhance student outcomes. The rings underneath the rainbow represent the various support systems that are used to make the learning process relevant and engaging. While most of these skills can be learned and/or developed through activities associated with any of the five ASETTS program badges, below is a list of how each skillset aligns with the activities associated with each of the ASETTS program badges (described in detail in Section 3):

- Key Subjects → Core Skills Badge
- 21st Century Themes → Awareness and Engagement Badge
- Learning and Innovation → Transportation Research Badge
- Information, Media, and Technology Skills → Transportation Core Skills Badge, Transportation Research Badge

- Life and Career Skills → Transportation Leadership Badge, Transportation Community Badge

Similar to the P21 framework, the ASETTS program integrated experiential learning which is the process of integrating classroom learning with hands-on experiences. Wurdinger and Bedon [*15*] suggest five teaching approaches for experiential learning including: "hands-on learning, using a problem-solving process, addressing real-world problems, encouraging student interaction with each other and the content, engaging in direct experiences, and using multiple subjects to enhance interdisciplinary learning." One of the most influential experiential learning models was developed by David Kolb [*16,17*]. This model suggests that the experiential learning cycle involves four stages—

- Concrete experience: In this stage, the learner participates in experiences. For example, this may include attending class lectures, going on field trips, conducting research experiments, etc.
- Reflective observation: In this stage, the learner reflects on the experience and synthesizes the experience for an extension to new domains. For example, while attending a conference, a student may be encouraged to reflect on a recent classroom learning experience.
- Abstract conceptualization: In this stage, the learner forms new ideas or modifies existing ideas based on reflection. For example, after reflecting on the research problem, the learner may adjust their initial perception (learned during lectures) of how best to solve it.
- Active experimentation: In this stage, learning is transferred to other settings around the learner. For example, developing innovative solutions to case competitions using classroom knowledge.

While experiential learning is increasingly being used in education curricula across the United States, it does present a few challenges that educators should avoid while applying these techniques. For example, the workload required to design experiential learning activities, time constraints, and class size have been identified as reasons why experiential learning is not used [*18*]. Strategies, such as breaking classes into small groups and aligning activities with the learning objectives of the course, are commonly recommended and employed during ASETTS activities.

Another alternative to increase student motivation with experiential learning is to use the digital badge framework. Digital badges have been used as stackable career credentials in industry and are used to identify the skills and competencies that an individual has acquired from professional development activities [*19,20*]. Students can list the badges they have obtained on their resume or LinkedIn as a means of illustrating their competency in transportation-related skill sets.

3 Design of Badge Program, Recruitment, and Execution

The ASETTS program was designed with stackable units whereby students are not required to participate in any specific activity nor are they required to obtain any specific badge. However,

to earn a badge, a student must accumulate the minimum number of points required for that badge by participating in qualifying activities. Figure 1 shows the structure of the badges and sample activities within each badge. By designing the program in this manner, fewer barriers to participation exist for students who work or have demanding class schedules.

While any student at NCA&T is allowed to participate in the ASETTS program activities, the primary focus group of the program includes undergraduate students enrolled in the Civil Engineering (CE) and Supply Chain Management (SCMG) programs. Over the last five years, the annual enrollment in CE has averaged around 134 students, with 145 students enrolled in Spring 2023. Similarly, the annual enrollment in SCMG has averaged around 92 students, with 111 students enrolled in Spring 2023. Among the enrolled students, underrepresented minorities (URM) represent an average of 70-90% of enrolled students in both CE and SCMG majors. As part of our execution towards the goals and the activities, the project team has implemented the following research plan and activities:

Formalize the digital badge program in collaboration with the endorsing agencies: The research team met with real-world transportation agencies and collaborated with the North Carolina Department of Transportation and the Institute of Transportation Engineers (ITE) as endorsing agencies. These agencies provided the inputs on the choice of badges and the potential list of activities to offer students.

Create a digital interface: The research team implemented an interface where students can enroll and track progress by submitting their attempts for completed activities. Previously, the research team used the Blackboard Learning Management System interface where the activities were posted as assignments that students were asked to complete. However, despite the fact that all students were already familiar with Blackboard, which was the primary reason for its initial selection, the engagement percentage using Blackboard was low. At the end of 2022, we shifted to a new interface called Suitable, which is a "mobile-first student engagement & success software that helps schools increase student participation outside the classroom, track and assess experiential learning and empower all students to tell their unique stories with our modern co-curricular transcripts." [*21*] The various Suitable interface screens can be viewed clearly on a

mobile application (Figure 4) and the Desktop dashboard (Figure 5) allows program administrators to easily monitor student engagement.

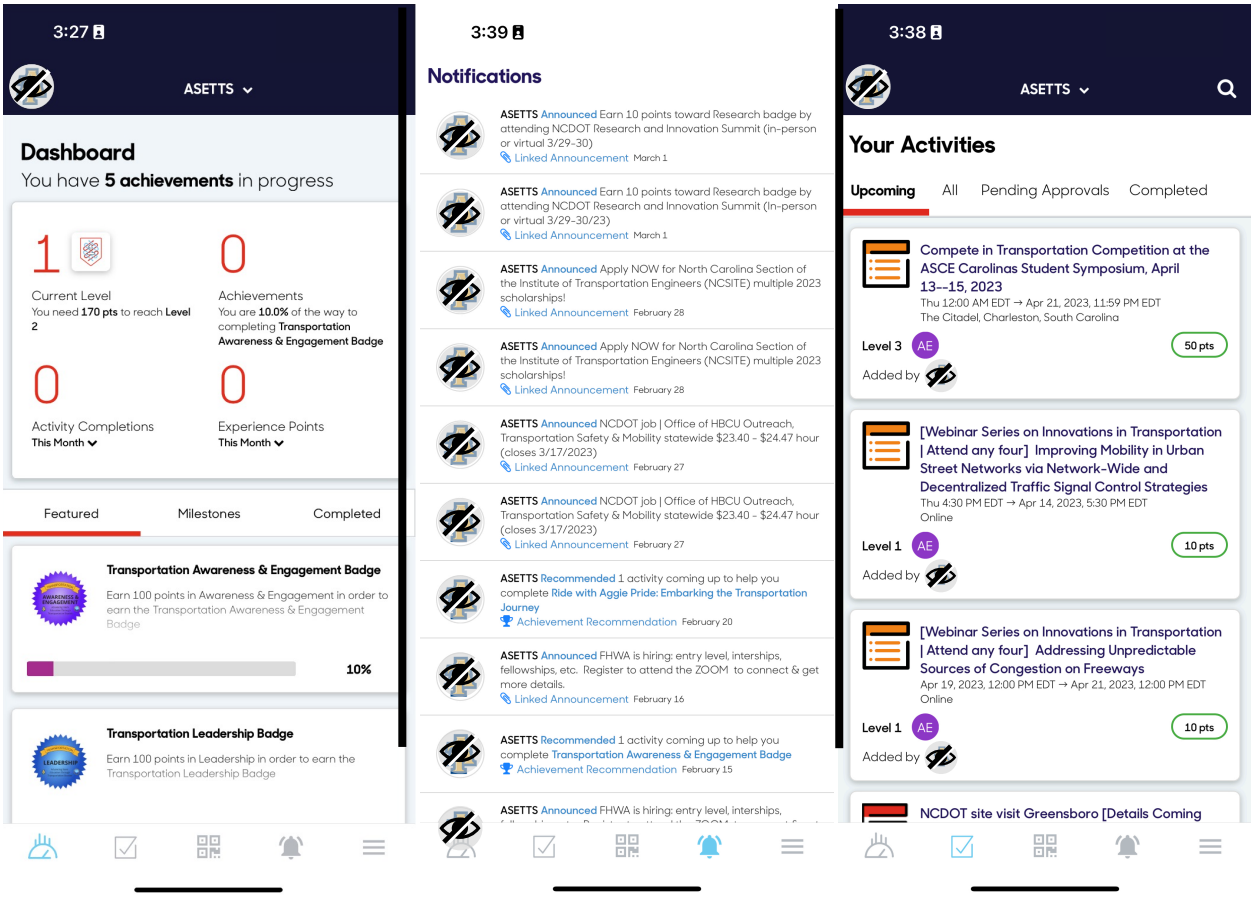

Figure 3 Three ASETTS program Suitable interface screens as viewed on a phone application

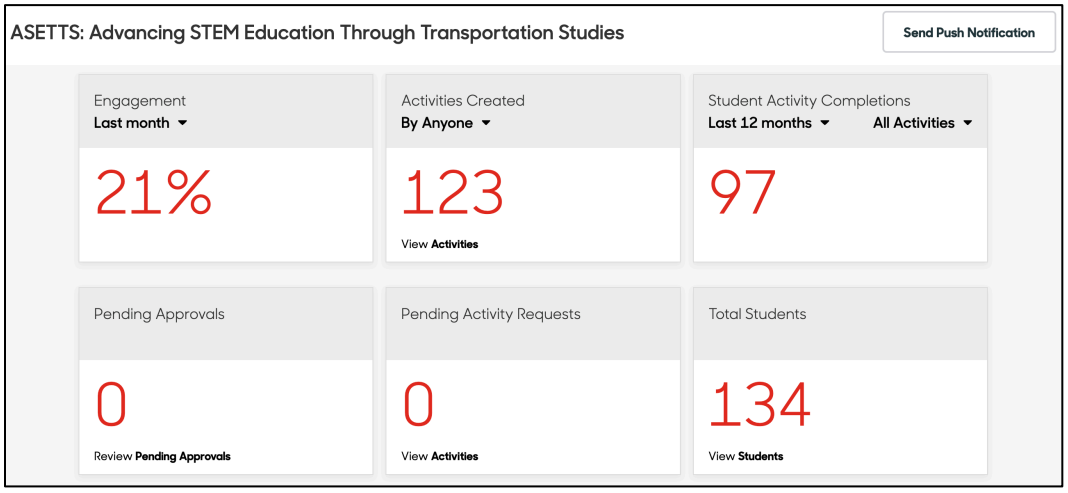

Figure 4 Dashboard for student engagement using the Suitable interface on a Desktop app

Improve the pedagogy of existing transportation courses: The pedagogy of existing transportation courses was augmented using components of the P21 and experiential learning

framework. The learning outcomes were updated to include the development of skillsets needed in the competitive job market. Specific experiential learning methods that were incorporated include (a) project-based learning and (b) active learning guided by the principle of how students learn. Table 1 shows current courses at NCA&T and examples of how the P21 and experiential learning frameworks were incorporated. The success of updated pedagogy tools was evaluated through formative and summative course evaluations.

Table 1: Examples of updates to existing courses requiring transportation skill sets

P21 and/or Experiential Learning Component	**Current course**	**Sample Pedagogy Updates**
Problem-based learning; active learning Technology skills; core skills	CAEE 240 Numerical Methods and MATLAB	Group assignments: Students will work together on real-world transportation examples using MATLAB Web interface: Students will experiment with parameters involved in numerical methods for differentiation and integration using a web interface
Service learning; active learning Core skills	CIEN 350 Transportation Engineering; SCMG 260 Introduction to Transportation (Supply-Chain majors)	MUTCD in action: Students will analyze signs and signals around Greensboro for their compliance with the manual on uniform traffic control devices (MUTCD) Case study: Students will analyze transit ridership in Greensboro and Raleigh and present solutions as a transportation case study
Project-based learning; active learning	CIEN 483 Transportation Design	Project-based learning: Students will be given the real-world example of transportation design and must use learned concepts to design the curvature and determine the level of service of a roadway

Match undergraduates with research opportunities on campus: For this activity, potential undergraduate students were identified and recruited to participate in research. Approximately seven students have been selected to receive research stipend support since the start of the program. We also provided undergraduate students with travel grants to present at and/or attend regional, national, and international transportation conferences, symposiums, and workshops. Furthermore, we also trained graduate students to serve as a mentor for undergraduate students on research topics.

Increase the exposure activities in transportation: As part of this effort, the research team organized additional activities such as field trips to transportation companies or research centers, hosted speakers and webinars on transportation-related topics, organized and prepared students for transportation competitions such as Traffic Bowl, and encouraged students to participate in

ITE Student Leadership Summit, symposiums by University Transportation Centers, and systematized the process of announcements for job, internships, and scholarship opportunities.

4 Findings from the ASETTS Program

The program has resulted in the engagement of 134 students thus far and has achieved tremendous traction among individuals. Figure 6 shows the key enrollment statistics (refer to the figure caption for details). As observed, the enrollment numbers indicate a jump near the start of each semester (September and February months) when the outreach activities are at their peak. The largest increase, observed near the end of January 2023, has occurred since the shift to the Suitable interface in November 2022, which has attracted more students to the program. We observe a majority of underrepresented minorities in our program and an approximately proportional split across gender and student classification (freshman, sophomore, junior, and senior). Civil engineering students dominate the group, followed by students in the supply chain management department, both of which have been the focus of our program.

Unfortunately, enrollment in the program does not necessarily indicate engagement. While the program has led to the creation of 123 activities across the five badges and one milestone, only a total of 97 activities have been completed by all students, accounting for approximately 28% engagement. We hypothesize that this low engagement rate may be due to the program's early development stage and anticipate an increase in engagement in future years.

Figure 7 displays the breakdown of activity completion rates by badge and graduation year for the students. As observed, the core skills badge has the highest completion rate, which can be attributed to students already completing the core courses as part of their curriculum, and several students pursuing transportation internships as part of the core courses. The "Career Exploration and Professional Development" milestone, added in January 2023, has received the highest engagement from students, which is impressive. However, since the program is still in the pilot phase, the community badge has not been rolled out to the students yet and is planned to be offered starting in Fall 2023, resulting in zero activity competition for the badge. When comparing the grouping of activity completion rates by the graduation date, we find that the engagement across sophomore, junior, and senior students is approximately the same.

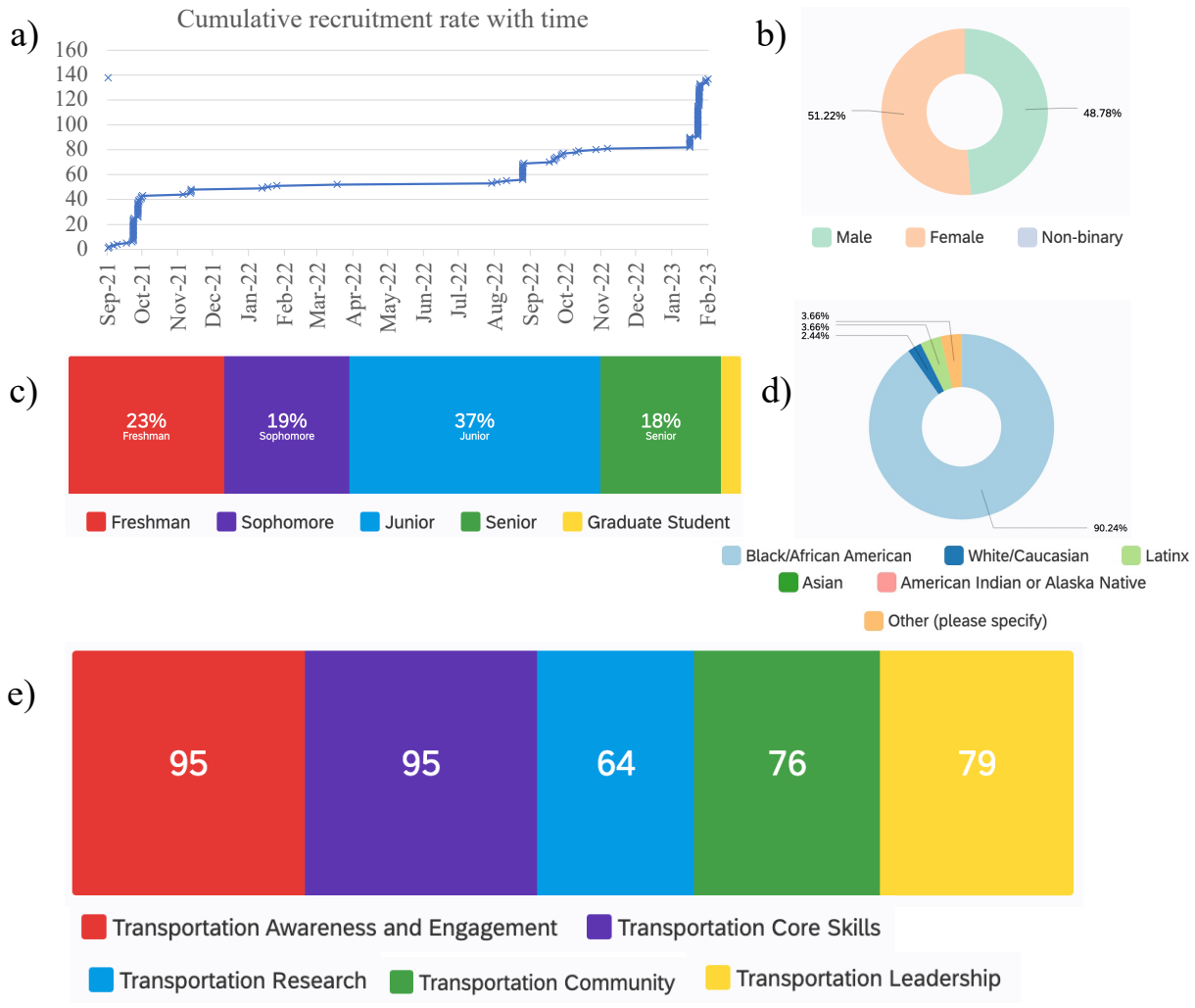

Figure 5: Enrollment statistics for the program: a) variation with time, b) grouping by gender, c) grouping by classification, d) grouping by race, e) number of responses with interests in a specific badge, and f) a word cloud of major/concentration for the enrolled students

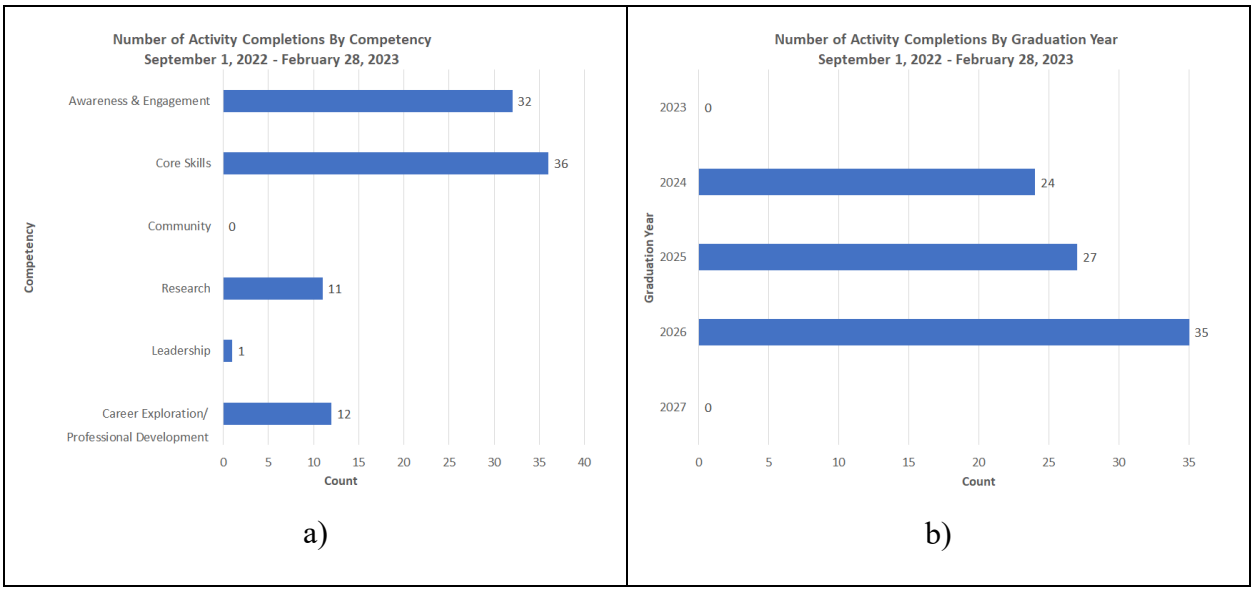

Figure 6: Number of activity completions (a) grouped across the 5 badges and (b) grouped by the graduation year.

A key finding from our program is that we observed a significant increase in student engagement once we switched from Blackboard to Suitable as the digital interface. In the first year of the program, the average number of completed activities per month was approximately six (across all students). However, the activity completion rate per month increased to 14 in the last month of February, indicating that a visually engaging interface that allows for easy progress tracking is useful for increasing student engagement. We have received valuable positive feedback from students about the interface.

The ASETTS program has engaged seven undergraduate students in research to date. We have found that the participation of undergraduate students relies on providing competitive stipends, offering students an incremental workload, and conducting periodic meetings to assess their progress and provide support with the technical challenges encountered during the research experience. Enforcing an incremental view of learning was also found to be useful in engaging undergraduate students in research, including asking students questions such as "what did you learn this week?" The anonymous reflection on their research journey provided by some of the students offers useful insights into ways the program can be strengthened (reproduced with permission):

> "*Prior to joining transportation research, I never thought that research could be something that I would be interested in, but because of Dr. Pandey's push and encouragement, I decided to dive into the world of research, and I am so happy that I did. Upon graduating, I had the opportunity to be recognized for my hard work, and got to proudly walk across the stage wearing my undergraduate research cord.*"—One of the program participants who excelled in research.

The experiential learning activities offered in the class designed for active engagement and learning were appreciated by the students who provided valuable feedback on what worked well. Excerpts from selected student feedback are included below:

> Question: What about the course is going well and what can be improved?
>
> Response: "*Ask more questions on the poll because it does help to see if we understand. Short group conversation/brainstorming allows us to see if we can come to the conclusion without knowing, or being told the answer right away.*"
>
> Response: "*Lecture slides are helpful and the polls with the examples. The examples on the polls and slides are very helpful*."

Several students participated in the field trips organized by the ASETTS program and found the experience very valuable. Sample reflection responses after a student leadership summit are presented below (reproduced with permission):

> Question: How did your participation influence your current understanding of the transportation system?
>
> Response: *"It made me understand how broad transportation really is. I know I loved transportation prior to this conference, but I didn't really think about what types of jobs I wanted to have and why. The conference is really pushing me to self reflect and come out to my interviews and jobs more confidently and with answers to any questions I may be asked."*
>
> Question: What next action steps did the event inspire you to take to become an informed transportation professional or leader?
>
> Response: *"It encouraged me to continue to do research about companies so that I can know exactly what I want & also go into rooms more confidently."*
>
> Response: "*It also encouraged me to apply for positions even though I may think I'm not qualified for them."*

As a result of our program, up to five ASETTS students interested in transportation careers have found internship opportunities in related areas, and four of them have secured transportation jobs. We have also observed that students who are most engaged with our program are typically in their senior or junior years (refer to Figure 8 leaderboard for students). This is primarily because students in civil engineering and supply chain management programs do not encounter transportation courses until their junior year, and are thus unaware of such opportunities. We note that this figure highlights the total points across activities completed by the students, and thus students who participate in activities with high points end up higher on the leadership. (For example, conducting research is worth more points than just attending a seminar.) The research

team has identified ways to engage freshman and sophomore students and will continue to encourage them to participate actively in the program.

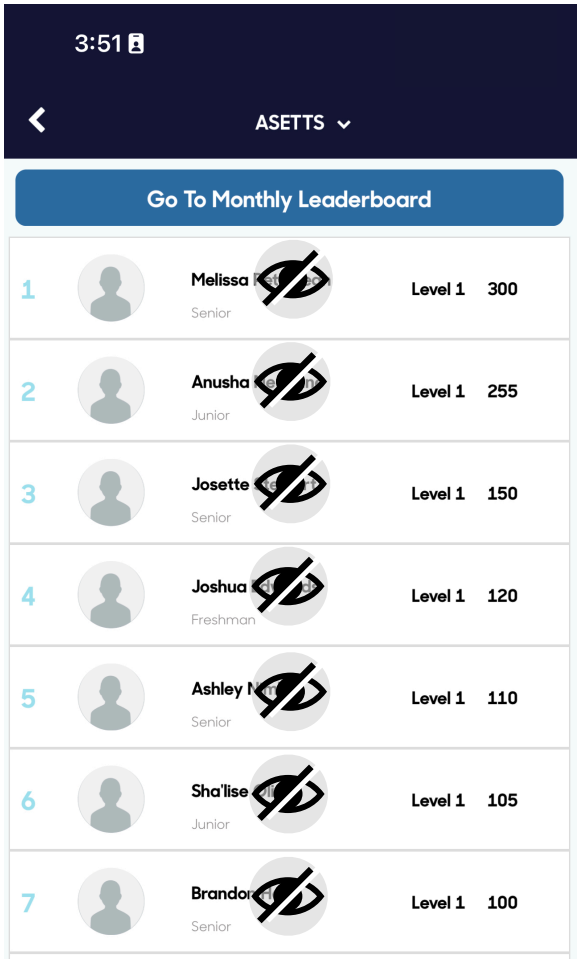

Figure 7 Leaderboard in February 2023

Finally, our research question stated in Section 1 is addressed by our observation of a significant increase in student engagement levels across various transportation-related activities. Although we lack precise figures to compare to the pre-ASETTS scenario, both anecdotal evidence and the observations of faculty members involved in the program demonstrate the effectiveness of using digital badges to prepare students for transportation careers. The ASETTS platform's activities also provide a low-barrier entry for students who struggle to find dedicated time to commit to a particular concentration within their major.

The program has faced some bottlenecks since Its initiation, including student reluctance to use online platforms due to pandemic fatigue. Table 2 highlights the identified problems within the ASETTS program and the proposed resolutions identified by the research team, which can serve as lessons for future digital badge implementations.

Table 2 Identified problems within the ASETTS program and proposed resolution.

Identified Problem	Proposed resolution
Slow momentum in research due to the busy schedules of undergraduates	Offer clear guidance and set clear expectations on what needs to be delivered and by when. Continue weekly advising meetings with the research mentor.
Lack of systematic ways for obtaining the data on job acquisition after graduation for students passing through our program	Conduct an exit survey and/or link with the University's database on this information.
Lack of post-activity submissions from students for program evaluation purposes	Develop more efficient student feedback mechanisms and provide the opportunity for students to complete them before departing the activity site.
Lack of participation in activities	Integrate activities into courses students are required to take in order to increase the likelihood of involvement. Work more closely with active student organizations from the start of the semester and conduct regular meetings with ASETTS participants to keep them engaged and maintain their interest in the program. Seek additional feedback from students regarding the barriers to participation or reasons why they do not participate in certain activities.

5 Conclusion

Transportation systems are at the core of the success of every society. As its key impact, the ASETTS program has enabled underrepresented students to become vital assets in the transportation workforce. In addition, through enhanced build-in motivation guided by the endorsed stackable-units digital badge program, this project demonstrates the potential to increase the enrollment and retention of students from underrepresented populations in STEM career fields. Furthermore, we envision that the potential success of stackable units will enable other universities across the nation and globally to use it as another tool for enhancing students' motivation and engagement in the classroom and beyond.

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