2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering
Education for 130 Years
ASEE
Paper ID #39588

A Pre-College Civil Engineering Course: Fostering Interest in Engineering Among High School Students and Developing Future Engineering Educators

Dr. Morgan R. Broberg, Purdue University

Morgan Broberg is a Research Engineer at the Purdue Applied Research Institute (PARI). She received a Ph.D. in Civil Engineering from Purdue University and a B.S. in Engineering from LeTourneau University. Her research interests include modeling, analysis, and design of steel-concrete composite systems and effective teaching in civil engineering.

Jose Capa Salinas, Purdue University

Jose Capa Salinas is a Ph.D. Student in the Lyles School of Civil Engineering department at Purdue University. He did his undergraduate degree at Universidad Tecnica Particular de Loja. His research interests include drone bridge inspection, routine and fracture critical (NSTM) inspections, the behavior of structures, earthquake engineering, student success, difficult concepts in engineering, and engineering education. He is a young member of the TRB Standing Committee on Seismic Design and Performance of Bridges and holds a Remote Pilot UAS license.

Danielle N. Wagner, Purdue University

Danielle is interested in enabling transparent communication between different members of society, often with an environmental focus to increase access to natural resources. She is currently a graduate student in the Lyles School of Civil Engineering at Purdue University pursuing a PhD in Architectural Engineering with a focus in indoor air quality. She has had several opportunities to engage in education with undergraduates and community members, and has recently been honored to be able to practice advising undergraduate service-learning teams. She was formerly a co-instructor for this weeklong Civil Engineering summer course for high school students, where she enjoyed creating interactive activities to build student's intuition of the indoors and built environments.

A Pre-College Civil Engineering Course: Fostering Interest in Engineering Among High School Students and Developing Future Engineering Educators

ABSTRACT

The development of the engineering workforce is a priority of engineering educators across disciplines. Domestically, the U.S. Bureau of Labor Statistics projects that approximately 25,000 new civil engineers will be needed each year of this decade. Given recent infrastructure legislation, many more civil engineers will likely be required to design, build, and maintain these proposed projects. Well-developed pre-college engineering curricula have been proven to increase student enrollment in engineering majors. However, these benefits depend on effective classroom technologies, tools, and techniques. This multi-year study looks at a one-week college-level course intended to foster interest in engineering among high school students and equip future engineering educators (graduate students who serve as instructors in the course) to use the current best practices in the classroom effectively. High school students should leave this course with a greater understanding of civil engineering as a field that presents real-world problems and offers innovative solutions, significantly impacting people's lives. Instructors should leave this course with real-world practice in applying innovative teaching methods for student impact. This course allows graduate student instructors to develop independent and authentic engineering class content while engaging with high school students to enhance their knowledge and interest in the field. This paper evaluates the effectiveness of this course over three years in two areas: (1) fostering interest in civil engineering among high school students, motivating more students to pursue this path in college, and (2) training graduate students (future engineering educators) on best practices for student engagement, knowledge transfer, and course design. Many data sources are reviewed for this study, including student artifacts, instructor lessons, and pre-and post- course reflections. These longitudinal data include the period impacted by COVID-19. As such, this evaluation also considers the effects of transitioning to online-only delivery, in-person teaching with COVID-related restrictions, and traditional on-campus instruction.

Key findings include the growth in civil engineering knowledge for each cohort regardless of delivery method. Learners consistently identified innovative activities like debates and live demonstrations as the most impactful for student learning. They identified hands-on activities and field visits as the most engaging and memorable. At the end of each course, instructors self-identified as gaining knowledge of research-based educational methods, greater ease in teaching and managing a classroom, and confidence in assessing student learning. The innovative teaching approach to pre-college education has encouraged new cohorts of high school students to pursue engineering as a career and current graduate students to pursue engineering education as a profession.

Tags: summer course, engineering, pre-college, STEM curriculum, high school, co-instruction, graduate student instructors

INTRODUCTION

Two of three U.S. jobs and nearly 70 percent of the nation's GDP can be attributed to scientific, engineering, and math activities [2]. Growth in engineering is necessary for U.S. economic growth and stability, boosting innovation and producing technology of value. Improving education in engineering, particularly in K-12, is critical to increasing the number of students who choose engineering as a career [3]. Moreover, exposing students to topics related to math and science leads to greater innovation and economic growth [3].

This connection between economic purchasing power and engineering is true across the world. For example, the Centre for Economics and Business Research, a UK-based economic forecaster, evaluated 99 countries to determine their engineering strength and connect it to financial forecasting [1]. Their study [1] proposed an Engineering Index, combining factors including the number and size of engineering businesses, investment and exports of engineering goods and services, engineering research quality, gender representation in engineering, and engineering worker salaries. The Engineering Index was then connected to an economic model to estimate the economic impact of engineering. Their study found a strong correlation between a nation's Gross Domestic Product (GDP) per capita and the Engineering Index: a 1% of the increase in the Engineering Index score resulted in a 0.85% increase in GDP per capita.

Engineering education can be a life changer for students graduating with these degrees in multiple aspects. The U.S. Bureau of Labor Statistics reports that engineering jobs are paid the highest average starting salary compared to other industries or occupational groups, with a median annual wage of $100,640 (from the available data as of May 2021) [4]. People with a B.S. in Civil Engineering earn a mean entry-level salary of $59,892 and annual wage of $95,490, suggesting they can sustain a reasonable quality of life immediately out of college. The American Society of Civil Engineers reports that 98% of engineers who answered their survey on job satisfaction in 2022 reported they were offered employer-sponsored health insurance, and 79% reported having a retirement plan through their employer, showing more engineers' salaries and benefits continue to increase in the U.S [5].

On the other side, engineering educators are needed to teach, support, and mentor the growing number of engineering students. Engineering educators often are Ph.D. holders who are experts in various engineering subdisciplines. However, engineering graduate students have fewer teaching-related professional development opportunities than students in other STEM subjects [6]. In other words, although experts in their respective fields, new engineering educators are often not education nor engineering education experts. Existing opportunities for professional development in teaching often lack essential features to enhance teacher learning. These features, presented in [6], align with the strengths of this summer course program, including multiclass activities, ongoing support in the classroom or online after the training, and opportunities for continuous education.

Developing engineering educators who are not only technical experts in various engineering fields but also trained and tested in engineering education is vital to fostering interest in engineering. The engineering education community has developed many proven techniques and research-supported methods. Still, engineering graduate students studying to be experts in other engineering fields are often disconnected from these communities. A study by Kluin [7] found that parents/caregivers' main concern when introducing engineering education to traditional classrooms was the ability of the instructors to teach these concepts. As shown by Katehi [6], progress will be slow and be measured most effectively decades after these lessons are introduced as learners enter the job market. Still, the potential to enrich and improve K-12 and pre-college STEM education is real, and engineering education can be a catalyst.

The program described herein attempts to bridge both gaps – inspiring potential engineering students to pursue engineering careers in college and training graduate students to be effective engineering educators. Through three years, the program has annually interacted with about 30 students and 3-4 graduate student educators. Students enter the program as rising juniors or seniors, and instructors are Ph.D. students with at least a year left in graduate school. As such, these former students are, at the time of writing, in high school (in 11^{th} or 12^{th} grade), their first year of college, or their second year of college. All former instructors are currently in academic careers, including continuing as Graduate Research Assistants, Postdoctoral Researchers and Fellows, Research Engineers, and Teaching Professors. Students have enrolled in Purdue's engineering programs and indicated a preference for civil engineering, but no formal statistics are maintained on previous students.

The course was first taught in the summer of 2020 and continues to be conducted every summer. Due to the COVID-19 pandemic, the summer 2020 instruction was entirely virtual, facilitated through the synchronous virtual lesson. The summer 2021 course was taught with many University-related COVID restrictions, including limitations on working closely together and busing students to other locations. The summer 2022 course was taught without COVID restrictions. Instructors were encouraged to consider these different contexts during the various years.

BACKGROUND

Engineering curricula are not exclusively tailored for college-level students. Engineering can be incorporated into the curriculum in the K-12 system, and the growing need for engineers in our industry has increased interest in fast integration in the last decade. However, many challenges come from this integration. First, many science teachers and the U.S. general population lack an understanding of engineering concepts and their applications [8]. Throughout the years, professional development opportunities for educators have risen to fill this knowledge gap and help instructors feel comfortable teaching an integrated engineering curriculum. As a consequence, student opportunities to interact with engineering curricula have risen.

The success of incorporating engineering concepts in classrooms before the college experience is plenty. A survey of 67 instructors teaching high school and middle school STEM classes determined that most students engaged more with engineering design projects than regular class activities. Teachers felt that 69% devoted more out-of-class time to work on their engineering project than in other subjects, and 95% of teachers felt students learned better science, mathematics, or technology taught through a design project [8]. The same study highlights the importance of having a professional development experience—some preparation before conducting a class embedded with engineering concepts—to make them more comfortable teaching them.

Cunningham et al. [8] identify two models for teaching engineering to students before arriving at college: stand-alone courses in which engineering is the organizer of student learning and courses mainly focused on science, mathematics, or technology where engineering concepts are embedded within the content. Regarding the former, stand-alone engineering courses have been added to popular organizations outside the traditional classroom, such as Girl Scouts [9], Boy Scouts [10], and 4-H [11]. In addition, universities and companies have also started offering engineering summer camps [12], [13] or outreach initiatives to their local communities [14]. Regarding the second model for teaching engineering students, courses embedding engineering concepts have been introduced in middle school and high school [8] in both public and private classrooms [15]. The results of these programs will be understood gradually as this student age and enter the workforce.

Summer programs can efficiently prepare students for college, particularly for first-generation, low-income, or racial minority students who are less likely to be ready for an undergraduate institution [16]. Some summer programs focus on being a transition program to remediate disparities from different educational backgrounds; others aim to introduce students earlier to topics to be covered in college; a third category is organized to increase engagement and provide fun activities embedded with learning opportunities.

Summer bridge programs are an essential tool offered by two or four-year institutions to pre-college students, particularly for people who may need an academic boost, since they supply educational and cultural tools to assist in their transition to college. In addition, they have been found to be effective in achieving immediate goals for college application academic requirements, increasing engagement, greater retention in their program, and providing long-term graduation rates. This type of program tends to be longer and more intensive but can make a difference when the student needs it the most.

Conflicting studies are present throughout the literature on the effectiveness of these programs. On the one hand, many studies support the theory that offering an intervention before students enroll in college will enable them to be better equipped for academic achievement [17]–[22]. On the other hand, the study presented in [23] criticizes prior findings on this program for limiting the rigor and generalization of the studies [24], [25] by focusing on a single institution [17]–[22], lacking control group [17], [21], [26], or limited following of students into subsequent years [17].

Little is known about short summer courses' effectiveness in increasing engagement and fostering interest. As shown in [27], some pre-college experiences expose students to general topics. Still, the lack of longitudinal studies does not allow institutions to see the benefit of summer courses and the work needed to improve them. This gap in the literature limits the ability of educators, two or four-year institutions, and stakeholders to promote, fund, or encourage this program for pre-college students.

The following longitudinal study explores the effectiveness of the curriculum, practices, and planning of a one-week summer course for high school students planned by engineering educators with autonomy on their content, assessment, and pedagogy. The study also describes the experience of the graduate student instructors and their learning throughout the course development and execution.

PROGRAM MECHANICS

The one-credit summer course occurred from Sunday to Friday during the summer session, generally in July. In addition to the instructors, students were assigned peer mentors to transport students around campus and manage students from 5 pm to 8 am.

Training Engineering Educators

This course is structured to help graduate student instructors develop and practice skills related to effective teaching education. This process starts with instructor recruitment, course planning, teaching allotment, and post-course assessment.

Instructor Recruitment and Schedule

The instructor recruitment advertisement circulates in the School of Civil Engineering in the fall semester. Midway through the fall, course instructors are interviewed and hired. Instructors were chosen to represent multiple civil engineering disciplines to demonstrate the depth and breadth of the field. Monthly meetings occurred through the remainder of the fall semester. Meetings every other week began in the spring semester and increased to weekly standing meetings two months before the class started in the summer. In year three, graduate students were given course credit for their participation in the Spring and Summer sessions. In addition, graduate students were paid in the Spring and Summer semesters, with returning instructors receiving a return bonus. After the first year, at least one instructor returned each year, mentoring new instructors.

Planning Process

Instructors are coached to use a backward design process in the course design process. First, instructors identify learning outcomes for the class as a team and then break these down into individual learning outcomes for each subdiscipline/instructor. Next, instructors research and select assessment methods, including formative and summative assessment strategies for the overall course and individual instructors. Then, instructors develop methods for grading and providing feedback before developing learning activities and associated grading aids.

Along the way, instructors develop the syllabus, rubrics, lesson plans, and online learning management system content. Instructors are encouraged to leverage resources and recommendations to facilitate learning in a highly interactive environment. Through the years, instructors have employed many techniques, including flipped classrooms, debates, jigsaw activities, and field trips. Instructors receive feedback on course documents and lesson plans from a full-time civil engineering instructor trained by the instructional excellence department. Instructors in year three were also required to visit the class of a highly-rated professor and sit down with them for recommendations.

Teaching Time

Teaching time was allocated to instructors evenly. In the morning sessions, students were all together, while in the afternoon, students were split into two groups to reduce the student-to-instructor ratio for specific activities. Instructors scheduled activities in the afternoon that were interactive, required specialized equipment available in limited quantities, or took place outside of the classroom. Instructors were encouraged to team teach on subjects or activities that were natural connections between instructors' content or expertise. An example of this collaboration was instructors teaching structural inspection and geomatics teaming up to teach about the use of drones in their respective fields, followed by a flight demonstration.

Teaching Assessment

Instructors received teaching assessments in the form of post-course surveys and evaluation surveys. In the third year, instructors received formal teaching evaluations from the department instructor who reviewed their teaching materials. Instructors completed post-course debriefs to review these evaluations and lessons learned from the course.

Fostering Interest Among Potential Students

The second goal of this program is to foster interest in civil engineering among high school students.

Student Recruitment

Students could sign up for the class starting in the spring with advertising performed by the school and Purdue's Think Summer Office. These applications are reviewed by the Think Summer Office before being sent to the school for final approval. Financial aid is available to qualifying students to reduce the cost of participation as necessary. Student participants were required to be currently in school in the U.S. or U.S. citizens in school abroad. Students came from over ten states. Students relocate to the campus for the duration of the program.

Program Content

Program content is curated to show prospective engineering students the variety and impact of civil engineering. Students are exposed to multiple disciplines of civil engineering, tour relevant facilities, complete hands-on activities, and interact with diverse engineers. Students are encouraged to see engineering as a creative outlet to impact real people's lives in tangible ways. At the end of the week, students have over an hour to brainstorm any additional questions about engineering, civil engineering, the university, admissions, or the course to ensure that students can ask any relevant questions while still on campus.

Student Assessment

Students are assessed based on the methods established by the instructor team. Each year, this has entailed a summative poster project with many formative intermediate assessments throughout the week. In addition, pre-and post-course surveys are also used to evaluate student growth and perception change between the start of the week and the end of the week.

PROGRAM OUTCOMES

The goals of this program are evaluated using student artifacts, instructor lessons, course evaluations, and pre-and post-course reflections. For each evaluation and survey, students were asked to rank their agreement from “Strongly Disagree” to “Strongly Agree.” They were also able to share feedback and answers via open-ended responses.

Before observing trends in the response data, it is essential to consider cohort-specific contexts. One primary consideration that may affect survey results is the COVID-19 pandemic. The summer 2020 cohort encompassed online-only students who hadn’t had in-person classes since March 2020. Although on campus, the 2021 cohort had COVID-19 protocols, limiting the number of students in a room and transportation to other sites. The 2022 cohort had the most students who knew each other before the course started.

Moreover, the instructor team varied from year to year. As such, although the program goals remain the same, the instructor cohort may also influence trends. Finally, although each set of respondents had generally similar positive responses, several evaluation categories included a solo student noting strong disagreement.

Training Engineering Educators

The course evaluations reveal the students' perception of instructor efficacy across various categories. The 2021 evaluations strongly agree with the instructor's use of appropriate materials, fair grading, organized instruction, and clear expectations. Overall, since the course's inception in 2020, instructors have improved in clarifying course goals, effectively organizing course materials, and setting clear expectations. This progress may be attributed to the program's ability to train graduate student instructors to achieve positive outcomes. Although the instructional materials' rankings have remained consistent over the three years, instructors can reuse or experiment with new lesson plans. This variability may explain students’ varying degrees of agreement regarding the complementarity of course materials, including lectures, reading materials, and assignments.

The 2021 and 2022 evaluations revealed that students highly valued instructor engagement but desired more. Specifically, in 2021, students appreciated the instructors' approachability and cared for the subject matter. Similarly, in 2022, instructors were praised for their knowledge, kindness, patience, and dedication, with one student expressing a desire to emulate them (“[I] can only hope to find my niche like them.”). However, students provided feedback suggesting a need for more opportunities to ask questions, both in-class and after-hours, which was challenging due to the course design and the structured daily routine. Nonetheless, the ability of graduate student instructors to create engaging activities for high school students was a clear advantage of the summer course. Teaching high school students also required more classroom responsibility, as these students were more likely to ask questions in class rather than communicate via email or discuss with the instructor after class.

Instructors anecdotally identified as better instructors after participating in the course planning and teaching process. Specifically, instructors self-identified as leaving the program with more educational tools, including knowledge of relevant pedagogies, backward design course planning approach, and many teaching activity ideas. Furthermore, instructors left with class evaluations from students, peers, and supervisors, giving them recommendations for future growth opportunities and materials to discuss with future teaching opportunities.

Fostering Interest in Engineering

The evaluation surveys' data for 2020, 2021, and 2022 cohorts were quantified by assigning a degree of agreement rating (ranging from 1-5) for each category, which included "Strongly Disagree," "Disagree," "Neutral," "Agree," and "Strongly Agree." The degree of agreement was then multiplied by the number of student responses for that category, and the weighted values were summed before dividing by the total number of students. The resulting averages for each category were organized by year and displayed in Figure *1*. It should be noted that the 2020 survey was taken virtually, while the 2021 and 2022 surveys were taken in person, increasing the response rate.

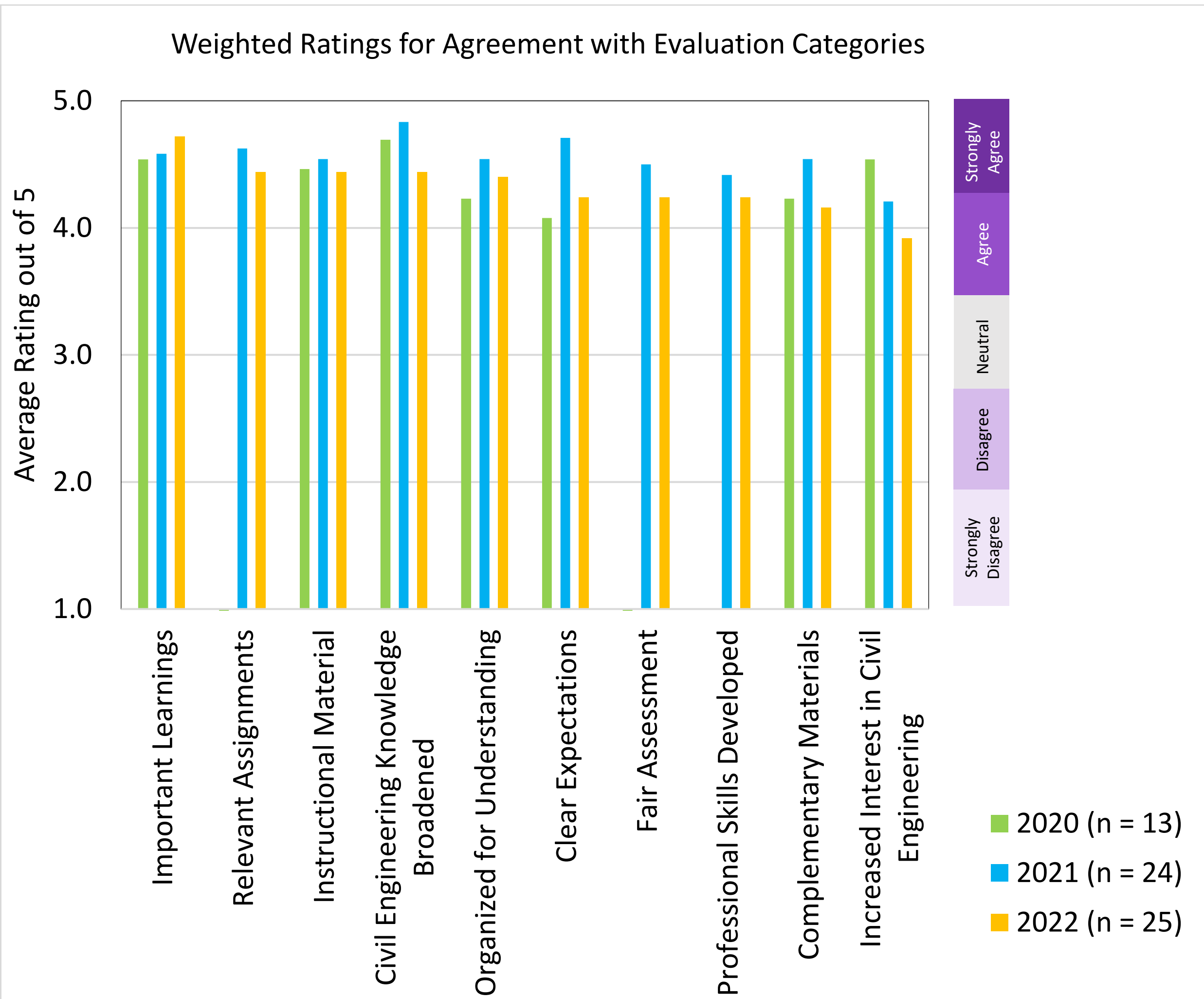

Figure 1. Student Agreement Levels on Course Content and Personal Outcome Statements

Figure 1 may suggest that civil engineering interest decreased in 2021 and 2022 compared to previous years. However, the average outcome for all years still indicates increased interest after course participation. Moreover, it is worth differentiating between the evaluation questions for each year. For example, the 2020 and 2021 surveys asked students about their general increase in interest in the field. In contrast, the 2022 survey specifically inquired about their interest in pursuing civil engineering as a career. Therefore, these questions serve as a general indicator of growth in interest in civil engineering while acknowledging a potential decrease in agreement for 2022.

Furthermore, 2022 pre- and post-surveys were analyzed to assess the level of interest in civil engineering as a career before and after the course. On average, the interest increased by about 0.70, equating to an increase from Neutral to Agree on the Likert scale. Eight students remained neutral throughout the course, indicating no increase in interest. Nine students already had an interest in civil engineering before the course. The number of students with the same interest in 2020 and 2021 is unknown. Although students in 2022 noted a slight increase in broadening their knowledge, the category still received strong agreement on average.

Most students associated civil engineering with infrastructure or bridges in the three-year pre-course surveys. However, topics covered throughout that year's week appeared in the post-course surveys. In 2020, the association shifted towards "sustainability" and "resiliency," while in 2021, students cited instructors' specific fields and considered factors such as "population growth," "ever-changing societies," "buildings adaptability," and "equity" when asked about civil engineering's future. The 2022 results showed similar trends, with students including terms such as "transportation," "hydrology," "technology," and "surveying" in their responses. The course increased students' awareness of the breadth of civil engineering each year.

An analysis of the students' responses whose interest in civil engineering increased showed a correlation between their ability to relate their creativity with the one used in their work. For example, one student highlighted a module that helped them connect with their team and utilize their geometry and art-oriented mind. On the other hand, of the two students who showed a decreased interest in the field, one demonstrated creativity but remained interested in more arts-based areas. The second student's decreased interest was unclear from the surveys. In the post-course survey, these students lacked specificity when describing "What Civil Engineers do," which could indicate a lack of interest in the survey or a failure to connect with the content.

Many positive reviews were based on specificity in the open-ended answers, where students could recall specific concepts or field-based logic. For example, one student noted in 2022 that it was "exciting to learn through trial and error and see my progress right in front of me," while another mentioned that it "was really interesting to see how the behavior of fluid changes based on certain types of obstructions." Based on these outcomes, it is essential to introduce specific concepts in accessible ways and gauge students' interests and methods of expression or creativity to help them understand how to apply them in their field of interest. Not only does unlocking innovation provide a variety of ways to allow people with different strengths and ways of learning to use them and enhance a diverse student body [28], but it can also help challenge and cultivate future problem solvers.

CONCLUSIONS

This longitudinal study discusses the outcomes of a program aimed to achieve two main goals: training graduate student instructors in effective teaching practices and fostering interest in civil engineering among high school students. The program accomplishes this by providing a comprehensive curriculum that exposes students to multiple disciplines of civil engineering, relevant trip fields, and well-designed content. The course also uses interactive and hands-on activities to engage students and encourage them to see engineering as a creative outlet that can have a tangible impact on people's lives.

The program has successfully achieved its goals, as evidenced by positive feedback from students and instructors. The program has attracted students from over ten states and consistently received high course evaluation ratings. In addition, the evaluations and surveys completed by students revealed that instructors had improved in clarifying course goals, effectively organizing course materials, and setting clear expectations. The course also increased students' awareness of the breadth of civil engineering and their interest in the field.

The program also equipped graduate student instructors for other teaching roles. These student instructors gained valuable teaching experience and mentoring opportunities. Additionally, the study highlights the need for more opportunities to ask questions and engage with instructors to increase students' interest. Overall, the program has successfully achieved its goals of training engineering educators and fostering interest in engineering. The program's success is mainly due to its comprehensive curriculum, detailed planning process, and commitment to providing a highly interactive and engaging learning environment.

Year over year, the program continues to innovate and adapt based on instructor and learner feedback. Anticipated future improvements include increasing the number of students in the program, expanding the graduate student instructor opportunity to other engineering disciplines and STEM fields, and reaching out to past participants (both students and instructors) to assess college and career outcomes. Overall, these improvements would increase the impact of the program and better measure outcomes of students and instructors experienced.

REFERENCES

[1] Real Academy of Engineering, “Engineering and economic growth: a global view,” Sep. 2016.
[2] Aerospace Industries Association *et al.*, “STEM and the American workforce.”
[3] V. Wadhwa, G. Gereffi, B. Rissing, and R. Ong, “Where the Engineers Are,” *Issues in Science and Technology*, vol. 23, no. 3, pp. 73–84, 2007.
[4] “Data for Occupations Not Covered in Detail : Occupational Outlook Handbook: : U.S. Bureau of Labor Statistics.” https://www.bls.gov/ooh/about/data-for-occupations-not-covered-in-detail.htm (accessed Feb. 13, 2023).
[5] “Job satisfaction among civil engineers high, new salary report finds.” https://www.asce.org/publications-and-news/civil-engineering-

source/article/2022/10/11/job-satisfaction-among-civil-engineers-high-new-salary-report-finds (accessed Feb. 13, 2023).
[6] N. R. Council, *Engineering in K-12 education: Understanding the status and improving the prospects*. National Academies Press, 2009.
[7] J. Y. Kluin and M. E. Cardella, "Parents' Concerns About the Inclusion of Engineering Education in P-12 Classrooms," presented at the 2012 ASEE Annual Conference & Exposition, Jun. 2012, p. 25.1025.1-25.1025.17. Accessed: Feb. 13, 2023. [Online]. Available: https://peer.asee.org/parents-concerns-about-the-inclusion-of-engineering-education-in-p-12-classrooms
[8] C. Cunningham, M. Thompson, W. Carlsen, and G. Kelly, "Integrating engineering in middle and high school classrooms," *International Journal of Engineering Education*, vol. 23, Jan. 2007.
[9] Girl Scouts, "STEM." https://www.girlscouts.org/en/raising-girls/school/STEM.html (accessed Feb. 13, 2023).
[10] Boy Scouts, "What is STEM and Nova?," *Boy Scouts of America*. https://www.scouting.org/stem-nova-awards/about-stem/ (accessed Feb. 13, 2023).
[11] "STEM & Agriculture," *National 4-H Council*. https://4-h.org/parents/stem-agriculture/ (accessed Feb. 13, 2023).
[12] S. Burkett, C. Small, C. Rossetti, B. Hill, and C. Gattis, "A Day Camp For Middle School Girls To Create A Stem Pipeline," presented at the 2008 Annual Conference & Exposition, Jun. 2008, p. 13.29.1-13.29.11. Accessed: Feb. 13, 2023. [Online]. Available: https://peer.asee.org/a-day-camp-for-middle-school-girls-to-create-a-stem-pipeline
[13] M. Ayar, B. Yalvac, F. Ugurdag, and A. Sahin, "A Robotics Summer Camp for High School Students: Pipelines Activities Promoting Careers in Engineering Fields," presented at the 2013 ASEE Annual Conference & Exposition, Jun. 2013, p. 23.98.1-23.98.18. Accessed: Feb. 13, 2023. [Online]. Available: https://peer.asee.org/a-robotics-summer-camp-for-high-school-students-pipelines-activities-promoting-careers-in-engineering-fields
[14] R. M. Hughes, B. Nzekwe, and K. J. Molyneaux, "The Single Sex Debate for Girls in Science: a Comparison Between Two Informal Science Programs on Middle School Students' STEM Identity Formation," *Res Sci Educ*, vol. 43, no. 5, pp. 1979–2007, Oct. 2013, doi: 10.1007/s11165-012-9345-7.
[15] A. A. Rogers, J. J. Rogers, and J. C. Baygents, "A Longitudinal Evaluation of an AP Type, Dual-Enrollment Introduction to Engineering Course: Examining Teacher Effect on Student Self-Efficacy and Interest in Engineering (Evaluation)," presented at the 2019 ASEE Annual Conference & Exposition, Jun. 2019. Accessed: Oct. 28, 2022. [Online]. Available: https://peer.asee.org/a-longitudinal-evaluation-of-an-ap-type-dual-enrollment-introduction-to-engineering-course-examining-teacher-effect-on-student-self-efficacy-and-interest-in-engineering-evaluation
[16] L. Coleman-Tempel and M. Ecker-Lyster, "Linked Coding: A Qualitative Investigation of the Impact of a College Transition Program," *Journal of College Orientation, Transition, and Retention*, vol. 26, no. 2, Art. no. 2, Dec. 2019, doi: 10.24926/jcotr.v26i2.2373.
[17] S. P. Ackermann, "THE BENEFITS OF SUMMER BRIDGE PROGRAMS FOR UNDERREPRESENTED AND LOW-INCOME TRANSFER STUDENTS," *Community Junior College Research Quarterly of Research and Practice*, vol. 15, no. 2, pp. 211–224, Apr. 1991, doi: 10.1080/0361697910150209.

[18] P. Garcia, "Summer Bridge: Improving Retention Rates for Underprepared Students," vol. 3, 1991.
[19] T. E. Gutierrez, "The value of pre -freshmen support systems: The impact of a Summer Bridge Program at UNM," Ed.D., The University of New Mexico, United States -- New Mexico. Accessed: Feb. 14, 2023. [Online]. Available: https://www.proquest.com/docview/304829060/abstract/139BB66539F2485FPQ/1
[20] T. E. Murphy, M. Gaughan, R. Hume, and S. G. Moore, "College Graduation Rates for Minority Students in a Selective Technical University: Will Participation in a Summer Bridge Program Contribute to Success?," *Educ Eval Policy Anal*, vol. 32, no. 1, pp. 70–83, Mar. 2010, doi: 10.3102/0162373709360064.
[21] T. L. Strayhorn, "Bridging the Pipeline: Increasing Underrepresented Students' Preparation for College Through a Summer Bridge Program," *American Behavioral Scientist*, vol. 55, no. 2, pp. 142–159, Feb. 2011, doi: 10.1177/0002764210381871.
[22] M.-V. Gold, M. Deming, and K. Stone, "The Bridge: A Summer Enrichment Program to Retain African-American Collegians," *Journal of The First-Year Experience & Students in Transition*, vol. 4, no. 2, pp. 101–117, Jan. 1992.
[23] H. Wathington, J. Pretlow, and E. Barnett, "A Good Start? The Impact of Texas' Developmental Summer Bridge Program on Student Success," *The Journal of Higher Education*, vol. 87, no. 2, pp. 150–177, Mar. 2016, doi: 10.1080/00221546.2016.11777398.
[24] A. Kezar, "Summer Bridge Programs: Supporting All Students. ERIC Digest," ERIC Clearinghouse on Higher Education, One Dupont Circle, N, Jun. 2000. Accessed: Feb. 14, 2023. [Online]. Available: https://eric.ed.gov/?id=ED442421
[25] H. M. Levin and J. C. Calcagno, "Remediation in the Community College: An Evaluator's Perspective," *Community College Review*, vol. 35, no. 3, pp. 181–207, Jan. 2008, doi: 10.1177/0091552107310118.
[26] J. C. Maggio, W. G. White, S. Molstad, and N. Kher, "Prefreshman Summer Programs' Impact on Student Achievement and Retention," *Journal of Developmental Education*, vol. 29, no. 2, pp. 2-4,6,8,32-33, Winter 2005.
[27] M. R. Broberg, S. Khalifah, A. Gupta, and A. J. Nafakh, "An Evaluation of a University-Level, High School Course Taught to Foster Interest in Civil Engineering (Evaluation)," presented at the 2021 ASEE Virtual Annual Conference Content Access, Jul. 2021. Accessed: Feb. 14, 2023. [Online]. Available: https://peer.asee.org/an-evaluation-of-a-university-level-high-school-course-taught-to-foster-interest-in-civil-engineering-evaluation
[28] A. W. Chickering and Z. F. Gamson, "Seven Principles for Good Practice in Undergraduate Education.," *AAHE Bulletin*, Mar. 1987, Accessed: Feb. 21, 2023. [Online]. Available: https://eric.ed.gov/?id=ed282491