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Metaphor and mentorship: a two-pronged approach and design of a framework for the development and retainment of first-year engineering students

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Metaphor and Mentorship: a Two-Pronged Approach and Design of a Framework for the Development and Retainment of First Year Engineering Students

This full paper submission (Complete Evidence-based practice) outlines the development of a novel first-year experience course aimed at increasing student retainment in the mechanical engineering undergraduate degree at a mid-size urban R2 institution. The program arose out of a need to ease the high school-to-college transition, close gaps caused by COVID-19 learning habits, provide a positive experience and connection to the university, develop students' sense of engineering identity, and increase student perseverance. The program, which occurred during the weekly recitation of the students' first year engineering course, employed a two-pronged approach; the first was the weekly activity that served as a metaphor designed to deepen first-year experiences, university-level study skills, address ABET professional skills, and interpersonal relationships; the second was the near-peer mentorship structure that helps to facilitate and support each week's activity. Students were assigned to mentorship groups based on several criteria, from highest to lowest weighting: math placement and ability, engineering course meeting pattern, and gender. Near-peer mentors were recruited and selected based on their relevant experiences and enthusiasm for helping the next cohort of engineers. Activities were developed using a metaphor framework based off story-based and narrative pedagogical practices. Pre- and post-course anonymous surveys were conducted for students enrolled in the first-year course. Likert scale questions were posed to evaluate their sense of belonging, confidence in pursuing and succeeding in engineering, and understanding of departmental and university resources. Over the previous three implementations of the program, the student response rate to the surveys ranged from 35% to 81% (Fall 2023-2025). This unique delivery has shown positive results with an average of 85.8% of student respondents each year self-reporting a sense of belonging, an average of 86.9% reporting confidence and persistence to pursue engineering, and an average of 76% of students reporting an understanding of departmental and university resources (with an absolute increase pre-to-post of 16%). With retainment as the ultimate goal, a first-to-second-year retainment increase of 7% year-over-year in each of the previous two academic years was observed. Additionally, the authors believe that one of the strongest signs of success in the program has been several alumni from the program (now upperclassmen in mechanical engineering) returning as mentors in the following implementations. This paper discusses the development of this novel first-year engineering program, the integration of metaphor-based pedagogical activities in a first-year engineering context, student observations and reflections on its efficacy, and its evolution throughout the five-year duration. Student feedback and assessment results are presented to guide further development of the program and academic support of first-year students.

Introduction

To meet the demands of a changing economy and society, it is necessary to substantially increase the number of STEM graduates and engage students to excel in STEM fields [1]. However, less than 57% of students who initially choose an engineering major will complete their program [2]. This paper aims to explain the novel first-year experience discussion class developed at The University of Akron to deepen the first-year experience of incoming aerospace and mechanical

engineering students called ZIPS: Engineered for Success (ZEFS). The inception of the program began with a discussion amongst professors about the attributes that make a successful engineering student - some of the traits described were innate, such as a passion for problem solving, but some were teachable, like time management and efficient studying – as well as addressing the reasons that students may leave engineering – while there are a small number of students that are not truly interested in an engineering career, external factors such as a lack of sense of belonging, academic preparation and support, and poor advising were also identified [3]. The final motivation for developing ZEFS was the effects of COVID-19, particularly the disruptive nature of hybrid and remote learning that provided additional hurdles to students' success and retention in engineering majors.

The cornerstone of ZEFS was to rebuild and strengthen the community that a year of hybrid and remote learning had disrupted, particularly to focus on the students' sense of belonging. Success has been shown in bridge programs that meaningful interactions with peers and faculty in multiple contexts led to increased student retention and sense of belonging [4]. This meant that ZEFS could not operate in isolation but needed to include people from across the department and college so students could become a part of the broader engineering community. Activities were designed and chosen for ZEFS to address concerns with academic preparedness and individual study skills, exacerbated by the COVID-19 pandemic. The methodology behind the course development, course outline, and results are discussed in depth. Survey results from students and observations from faculty members are shared as evidence of the success of the program. This work demonstrates the initiation of the program and focuses on the course development.

Experimental Methods/Materials/Project Approach

The course development committee began its discussions with two major questions: "Why do students leave engineering?" and "What makes a successful student?" The first question led to a discussion of the stress students face, lack of knowledge of available resources, and not knowing how to use the tools required for academic success. The second question led to discussions centering around students' passion and motivation, their understanding of how education fits into their end goal, and their soft skills, including organization and technical communication. The ZEFS program was designed to address the deficits that may lead to students leaving engineering, as well as providing opportunities for development of these traits of a successful student within several contexts.

First-year Introductory Course

At The University of Akron, incoming first-year engineering students are enrolled in an introductory tools course for their first semester in the College of Engineering and Polymer Science. The course comprises of a lecture section, two laboratory sessions, and a discussion session each week for 15 weeks. The discussion sessions combine all aerospace and mechanical students between two sections; both disciplines are included as they are part of the same department. The ZEFS program described in this work takes place during the aforementioned discussion period.

The goal of the ZEFS session is to actively engage students with each other and introduce, practice, and refine the soft skills that a typical first year engineering program may overlook. While many first-year programs focus on technical skills and content, the role of ZEFS is to focus on teamwork, communication, and ABET professional skills. Attendance is taken at the end of each lesson and factors into a small portion of the students' tools course grade. A two-pronged approach is utilized to fully address the concerns and challenges facing incoming first-year engineering students; the first is the use of near-peer mentors to form connections within the major and initiate that sense of belonging; the second is the use of metaphor-based activities to introduce essential skills for success and retainment of students in engineering. The students are seated in groups of 7-9 students, each with a near-peer mentor. At the start of class, the topic for the day is introduced and the activity to demonstrate that lesson is briefly explained. The students then work together in their mentorship groups to accomplish the activity with the guidance of their mentor. The discussion session is open to all faculty members to attend; when they do, faculty are either encouraged to join a student group and participate in the activity for the day, or they will hold a "judge role" for competition-style activities.

In addition to general faculty invites, each week a different faculty or staff member from the department serves as the 'host' and leads the activity. The host also facilitates the concluding remarks on the activity, its results, and the metaphor that it represents. This allows for incoming first-year students to easily meet and interact with multiple faculty members from their department that, by serving as hosts for the ZEFS activity, have demonstrated that they care about these students and thus contribute to that sense of belonging and lead to stronger retention and persistence outcomes [4].

Groups

Through several iterations of the ZEFS program, the optimal group size was determined to be 8 students to 1 peer mentor. Prior to first ZEFS session, mentorship groups were formed primarily based on the students' math placement. Anecdotally, math courses are among the hardest for incoming first-year students, and their math ability is an indicator of their persistence in engineering. By forming groups based on the math level and tools course section, students are naturally encouraged to form peer support networks and study groups. Secondarily, groups were reviewed to avoid overwhelming gender imbalances. The third weighting criteria was enrollment into a particular laboratory section. The motivation was again to provide an opportunity for the students to work with peers they see multiple times a week to help form their support network.

Two-pronged Approach: Mentorship

Near-peer mentorship is a critical facet to the success and implementation of ZEFS, and mentors were selected on a volunteer basis. The mentors are typically juniors or seniors in the major. These mentors served as a dynamic resource: they are able to adapt as the semester continues, facilitate group activities, and reach out to troubled students individually in a low-stakes manner. Mentors served as role models and were available to students during and outside the course time. It has been shown that peer mentoring can often be effective in providing academic behavior role models as students are often more open to accepting advice from peers. From past testimonials,

one-on-one experiences are often the ones that make the biggest difference for students; group mentors were a way to provide that opportunity on a weekly basis. Mentors also promote knowledge transfer in a different method than their courses: first-year students will be able to ask someone who has been in their shoes what the best path forward is and what resources were most helpful. The mentors are assigned, where possible, to groups that started at the same math level as they did during their first semester.

One concern for retention is the buildup of frustration by young people and not being able to detect when a student is having trouble until it is too late. The mentors serve as a flagging system, with only 7-9 students in their group, they can alert the professor when a student is frequently absent, or if a student is consistently stressed, overwhelmed, or disengaged during ZEFS. This provided the instructor and the department with time to try and provide resources and help to the student before where they left the major.

Two-pronged Approach: Activities

The program is designed as a non-class course, where lectures, videos, and slides are prohibited. Instead, the lessons are taught through activities that serve as a metaphor.

During formation of the program, the second question helped formulate most of the topics. As previously stated, a successful student has passion for engineering, an understanding of how their education drives later success, and knows how to communicate. Working on the assumption that there is passion for engineering (since the students selected an engineering major), the proposed work focused on developing a mentality that will allow students to take full advantage of their time in the program. The first week of the program introduces students to one another and their mentor with an icebreaker. Students are then introduced to different study methods for long-term learning opposed to cramming. In week 3, alumni visit and share the "carrot" for the tough course load, what an engineering degree can lead to post-graduation. The following weeks build the mentality of collecting various tools and skills, including building a resume and professional network. The opportunity fair is a college-wide event where all student clubs, design teams, and organizations gather along with undergraduate research opportunities for the students to explore extracurricular activities to help expand their toolbox and deepen their sense of belonging to the University. The opportunity fair is also an internal chance for students to test their networking and resume. Around midterms, a lesson on failure and how to learn from it is included. The comparison between the bachelor's and technology degree is included shortly thereafter in response to a trend of students doing poorly on their math midterms and then switching programs to an 'easier engineering without math'. Prior to the start of the scheduling window, students are given the chance to formulate a four-to-five-year plan for their courses and meet with advisors. Technical report writing follows as the lab report deadlines for other courses approach. The engineering design cycle is reemphasized (originally shared in lecture) to help students finish their semester design projects followed by a week on engineering ethics. Before the end-of-semester rush, stress management teaches students how stress can be viewed positively if managed appropriately and demonstrates various tools for reducing stress. The last week of the semester is stress-relief time; students participate in a fun activity with pizza and professors to

celebrate the end of the semester, relax before finals week, and make a positive memory to carry through winter break.

Table 1. Topic outline for Students: Engineered for Success for ME/ASE students.

Week	Activity
1	Ice Breaker Challenge
2	Studying
3	Intro to Your Discipline
4	Resume
5	Networking
6	Opportunity Fair
7	Overcoming Failure
8	Engineering vs. Engineering Technology
9	Your Plan (and Scheduling)
10	Report Writing
11	Engineering Design Cycle
12	Ethics
13	Stress Management
14	Mini boat competition

Activities must be time efficient, so they fit in the 50-minute period of class and clearly emphasize the activity's lesson. For example, in Week 4 the topic is resumes. The introduction will outline what the purpose of a resume is and how students need to utilize their time in college to build skills to fill a resume. The proposed hands-on activity begins with each group asked to construct a customer requested object from a random handful of Legos. After the Legos are selected, the host tells the class what they'd like them to build (ex. an airplane). Creativity will be required to accomplish the task with such limited resources. Then, the groups will share what they built with the others. The next portion will use the same customer requested object, but students are able to pick the materials they wish to use. The activity's conclusion demonstrates how challenging building the object was with such limited resources, (i.e., crafting a sellable resume with limited experiences is difficult). Whereas collecting different resources (i.e., variety of skills) and good quality resources (i.e., learning versus memorizing) makes obtaining and fulfilling the project requirements (i.e., interview, job placement, and career) easier. The goal is for students to begin thinking about what their career end goal is, and how to obtain the skills and experiences during their time in college. If students are unsure of what their dream job is, then they will need to collect many more diverse skills so they can obtain the desired job when they do decide.

Assessment

The majority of the assessment on the success of the program was conducted through surveys and was supplemented with college retention data and faculty/student observations. At the start and end of the semester the students were provided with the opportunity to participate in an anonymous survey through their lecture portion of the first-year experience. The IRB reference number for these surveys is IRB #20220501. The surveys included questions about the students' sense of belonging, ability to succeed, and knowledge of university and departmental resources. Likert scale questions were used and a negative control question about the ability of woodworking was included. The College of Engineering and Polymer Science collected retention data using the University of Akron census data (collected after the drop date in the Fall semester).

Results and Discussion

Retention Results

The University of Akron is classified as a Carnegie R2 urban university. The population is 66.55% white and 50% male. The University of Akron has a large portion of students who commute to campus and 87% of the population are in-state students. The combined Mechanical and Aerospace Systems programs form a cohort of approximately 180 students each year comprised of 86% male and 14% female. From a retention standpoint, the impact of ZEFS has been overwhelmingly positive, with an absolute year-over-year increase of 7% in each of the years since the ZEFS program was implemented. Though mechanical engineering was not the only major to post retention gains year over year, it was the largest increase in retention rates which can be directly attributed to the success of the ZEFS program.

Student Survey Results

The student survey results were positive overall and demonstrated that the program was achieving its goals of improving the first-year experience. Questions were posed as Likert-scale statements (5 being strongly disagree, 1 being strongly agree, 3 was neutral) and can be found in Appendix B. Positive responses were considered as any score above neutral (3). A negative control question, which asked the students about their woodworking ability, was included as part of the questionnaire, and the results showed negligible change from pre- to post-survey within each ZEFS cohort (Table 2). Table 2 shows the percentage of positive responses from students that feel they are comfortable making wood furniture. Due to the anonymous nature of the survey, authors do not have a way of tracking which pre- and post-surveys are from the same students; the negative control question indicates that the pre- and post-survey responses match relatively well. The post-survey is done at the end of the semester which accounts for a lower participation rate. A potential source of bias is that the end survey likely does not include students that have dropped the program during ZEFS, and would likely bias the end versus start responses.

Table 2. Positive Responses to the negative control question.

Year	2022	2023	2024
Pre-Survey (% of respondents)	64	59	66
Post-Survey (% of respondents)	55	51	65

Concerns of student preparedness for engineering courses and organizational and study skills were evaluated with two questions in the surveys: 'Q5: I feel confident about managing college-level classwork' and 'Q12: I know how to be a successful engineering student'. Students who responded in a positive manner are represented in Figure 2 below. There is a consistent increase in the level of positive responses in almost all of the years for both questions. This success is attributed to the lesson on different learning styles, formation of study groups from students' social interaction over the semester, and the opportunity to collaborate with their mentors each week. Throughout the semester, different college-level resources such as tutoring were shared with students, and it was continually reinforced that engineering is a team sport and study groups will help the students to be more effective at studying.

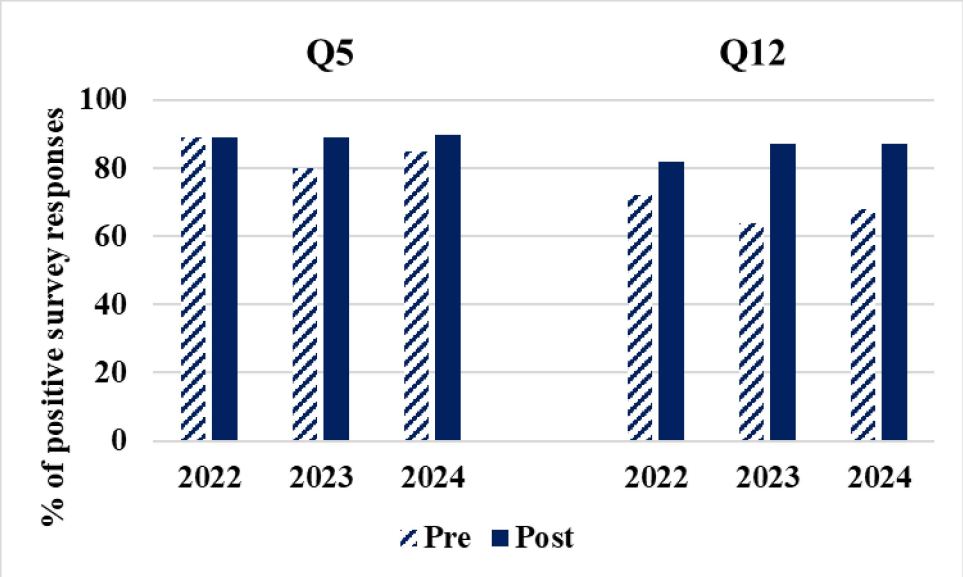

Figure 2. University-level study skills gained according to student surveys.

ABET has requirements for development of professional skills which the ZEFS program aimed to help meet. Since the start of the program as a formal portion of the first-year experience, there have been many qualitative positive trends observed by instructors and surrounding faculty. One of those is an increase in student involvement in design teams and undergraduate research. There are many hypotheses for why this result occurs: alumni (speed-mentoring week) emphasize that they look for this participation when hiring and that they themselves participated, mentors are involved in campus activities and advertise to their groups, and faculty members are able to share their research interests. Since the faculty discuss undergraduate research in a more casual environment, students seem to be more willing to approach them and inquire about opportunities.

The opportunity fair has been another major contributor to the increased undergraduate involvement in engineering activities. The opportunity fair is held 5-6 weeks into the semester when students feel comfortable on campus and have developed their routines and have a more accurate feel of their availability during the week. All the design teams, clubs, and undergraduate researchers with open positions participate in a tabling event where first-year students can visit like a job fair and learn which opportunities best fit their schedule and interests. The opportunity fair has become a college-wide event based on initial success of design team and engineering club enrollment.

The core of the program is to strengthen the engineering community for first-year students. Questions 6, 9, and 10 were used to evaluate the success of the program in this regard. 'Q6: I feel confident about managing college life,' focuses on the individual but it is a byproduct of fitting into their community and knowing the people at the University of Akron that can help them if needed. With exception of one year, this metric was shown to increase from the pre- to post-survey. Questions 9 and 10 demonstrated marginal increases in the first year and significant increases in 2023 and 2024. 'Q9: I know one of our ME professors well enough that I feel I can approach him/her if I have questions or need help', can be linked to increased faculty participation in ZEFS, especially in recent years. While a different faculty leads each ZEFS session, the Networking activity additionally brings in about 10 faculty members to directly participate in the activity for students. 'Q10: I have a peer group that would support me', has similar trends to and offers direct confirmation that the program allows students a headstart in creating a meaningful community and reinforce their sense of belonging. While there are opportunities outside of the program that would allow for this support system to form, the instructor has observed direct impact of the program in forming this peer group in each cohort. There are pairs or smaller groups of students from each assigned group that maintain the study groups formed from class. This trend has increased as the filter for math class and then lab section, which groups students by the sections they are enrolled in, has been implemented. Readers will notice that in Fall 2022, incoming students were more confident about managing life than in other years. In 2022, course instructors demonstrated varying levels of support for the program; some gave credit for ZEFS attendance whereas others did not. As expected, this impacted student attendance. While the section data was not tracked in this year, the authors believe instructor support skewed the participating population per section and towards more prepared students in all sections. This demonstrates the importance of having the program count for a portion of the student's grade to strengthen the 'mandatory' aspect of the program and tracking individual student data.

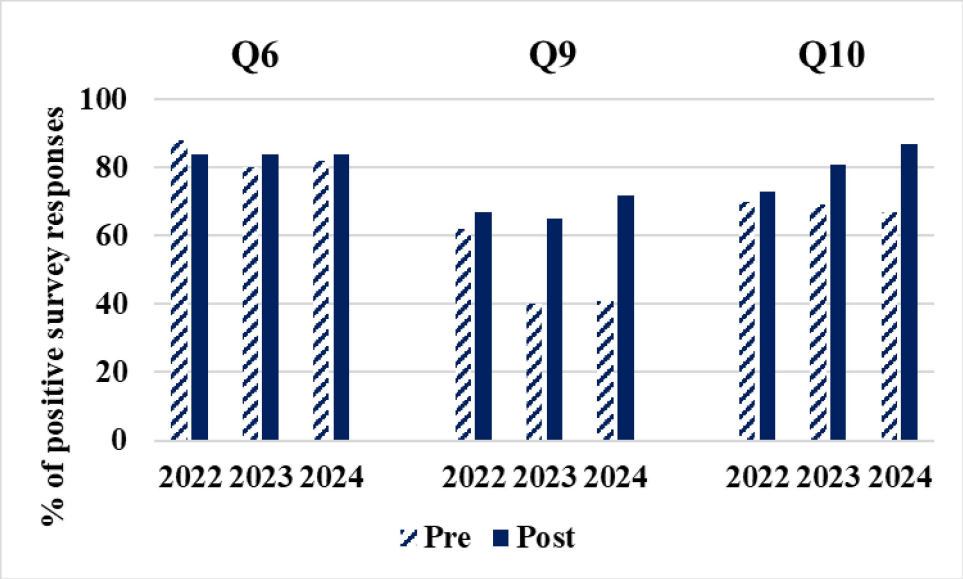

Figure 3. Interpersonal Skills gained according to student surveys

A student's sense of belonging in multiple contexts was evaluated with two questions from the survey that asked students to rank their sense of belonging to the university (question 13) and their sense of belonging to the college (question 14). The results do not show a large change in the sense of belonging to either community. This could be for a variety of reasons – the first is that the post-survey response rate is substantially lower than the pre-survey response, and that the data are not linked to individual students. The second may be that by the time that post-survey is given to students, a small number have decided to leave the major. And finally, due to the timing of the post-survey at the end of their first semester in university, it could be that students are now more aware of what is required for success in engineering and are more carefully reflecting on their sense of belonging. Despite the mixed response towards a sense of belonging, the year-over-year increase in retention still speaks to the success of the ZEFS program.

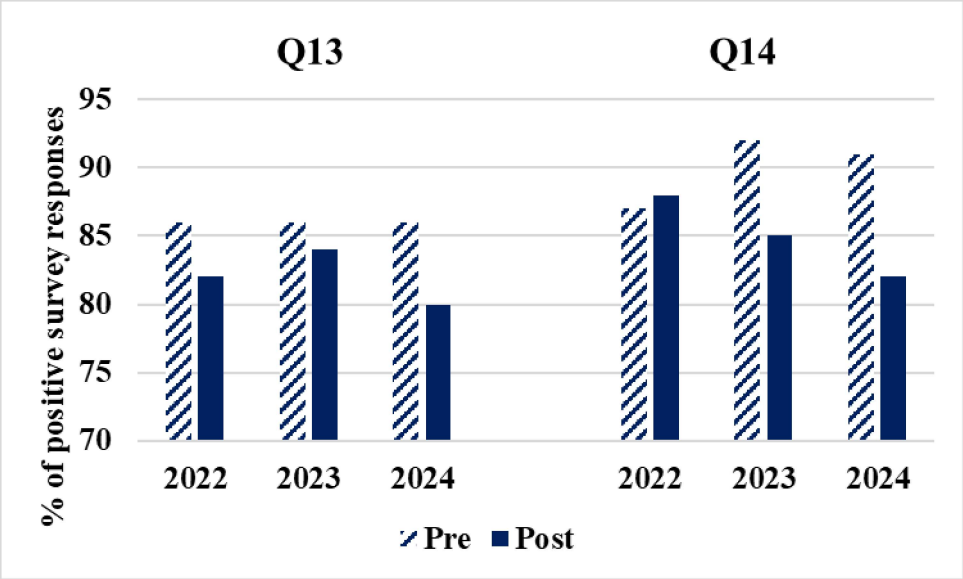

Figure 4. Sense of Belonging gained according to student surveys

Ensuring that students are aware of resources available to them on campus was of the upmost importance to program founders. It was believed that a significant portion of the students lost to the program were not from a lack of interest but a build-up of frustration. For young adults, having hard coursework creates a baseline of stress and then an unresolved issue added on top would lead them to leave the program not for an engineering issue but because of a resolvable resource problem. Authors wanted to ensure that students knew all the available resources to help them resolve problems early before it led to the level of frustration where they left the program. These potential problem areas were grouped into three primary areas: academic (question 7), financial (question 8), and faculty-solvable such as program questions (question 9). Overall, the survey responses point to the students gaining knowledge about all categories of resources throughout their first semester.

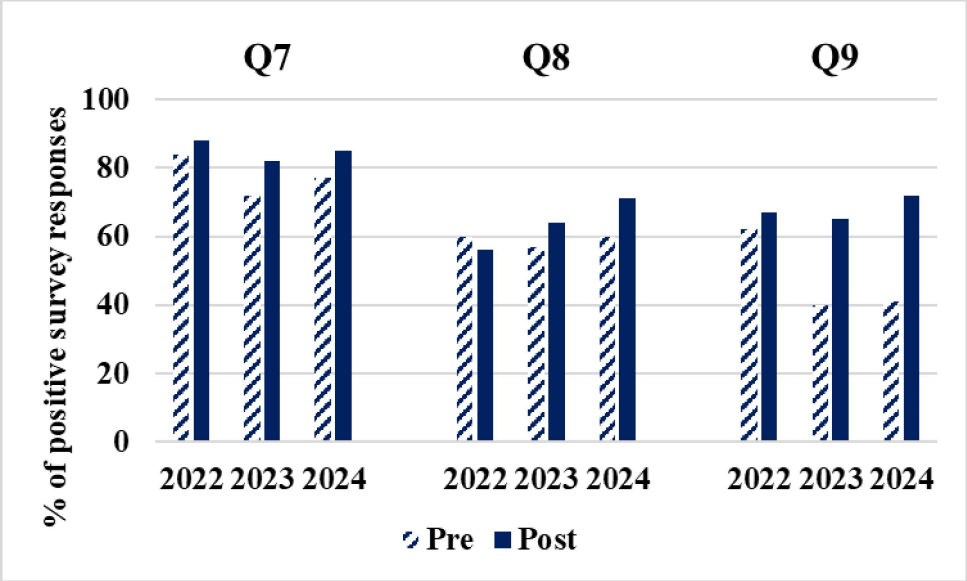

Figure 5. Knowledge of Available Resources gained according to student surveys

At the end of the anonymous survey, students had a chance for extended response questions. The first question asked what portions of the course were most helpful to their learning. The table below documents a sample of their responses. Students shared that they enjoyed being in a dynamic environment that provided an easy opportunity for them to make friends in their major. Another highlight was the peer mentor who was able to help with many of their questions. The professors also seemed to have a positive impact on the students, with some saying they enjoyed getting to talk with them outside of a typical classroom setting; a sentiment already demonstrated in the literature [4].

Table 3. Anonymous Responses to the most helpful aspects of the course.

"Being with a group of peers that stayed the same throughout the semester"
"The professors coming in and talking about ways to help throughout the semester"
"Fun activities that relate back to engineering and good information about opportunities"
"The invitation of other professors to engage deeper and meaningful topical conversations"
"Discussions preparing us for life"
"The peer leader we had was very nice and gave great advice for what's to come ahead and some of the lessons were useful such as the planning one"
"I think it was fun but to be honest didn't get much out of it other than friends"
"The class pushed me out of my comfort zone and forced me to interact with people"
"I think this class was very much a way of motivating incoming freshmen for a difficult major. It taught you a more philosophical side to engineering and engineering school"
"It really helped me to adapt to college life while also learning about engineering"
"The ability to meet other people with similar majors that I could ask questions if I needed help"

"The mentors were a great help whenver my group had questions, needed feedback, or just needed some encouragement. Plus, the whole class seemed to be hands-on activities and really engaged myself in learning"

The second extended response question asked about what aspects of the course you would change to improve your learning. There were fewer responses overall to this question but one comment that stands out is “Stop treating a group of 19 year olds like kindergarteners; teach real ideas instead of giving us Legos and saying its like a resume”. This response highlights the importance of the mentors emphasizing the metaphor and helping the students to understand. The course was not designed for everyone and students who already have these soft skills and/or goal-oriented mentalities will not appreciate the metaphors. As the course has developed, making sure the mentors understand the metaphor itself and help explain it to the students (in addition to the host’s explanation) has proved critical. Since the mentor position is by volunteering, each group’s experience can vary based on the strength of the mentor.

Lessons Learned

When the program originally started (prior to 2022), it was optional for all first-year aerospace and mechanical engineering students. Pizza was provided to incentivize students and mentors reached out via email if the students did not attend the program. After the first few weeks, only the students who did not need the program continued to attend (the top performing students who already were rarely absent, knew how to seek help and had many of the skills they needed to succeed from high school). Authors believed the majority of students that were leaving the program were those considered the bottom 40% based on their current math course, attendance in classes, and incoming study skills. In subsequent terms, the program was then made mandatory, with attendance counting for 10% of the students’ overall first-year course grade. After this change, consistent attendance was achieved and the retention numbers started to increase and consistent attendance was achieved.

Another lesson that instructors learned was the importance of the ice breaker in week 1. Before the ice breaker, week 1 would start with an intended lesson and activity just as the other weeks in the class are run. When students would come into class, a few would talk but the majority were on their phone or would just sit there until the instructor started class until weeks 6-8 when the students would start coming into class and interacting with each other and their mentor. When the course started with an ice breaker the first week which asked what each student’s biggest challenge was that day, week, month, etc. it was observed that the students coming in and talking to each other and the mentor started about weeks 3-4, almost a month earlier.

An ongoing lesson instructors are learning is that a quick gauge of the success of a lesson is the number of phones out. The first few semesters of the project, it was clear which lessons needed revamped because they were the ones where students would be on their phone during class. When a lesson was most successful, students were completely engaged and no phones were present.

Future Work

With ZEFS having demonstrated success in aerospace and mechanical engineering, there is now work to expand the program to other departments. The biomedical engineering department (about 60 students per cohort) is working to adopt the ZEFS course with a biomedical engineering context, adjusting activities to be more relevant to their program goals. The aerospace and mechanical engineering department has also expanded the program to continue in the spring semester so students get more interaction with a mentor guiding them on their design projects. The first-year experience includes a semester long project in the spring so the ZEFS course emphasizes techniques for successfully working in groups, project management skills, and provides guidance when conflicts arise in each group.

The current work of the ZEFS team is to develop the program from one specifically designed for the ASE/ME department into a flexible framework that can be easily adapted by other departments. As more departments start the program, a longitudinal study to follow students and their path to completing their degree would like to be conducted. It also gives the option for studying how the program works or needs adapted for programs of different sizes. The three departments using the program are cohorts of 180, 60, and 40 students so instructors are excited to analyze the adaptations needed for each class size.

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References

[1] S. Olson, and D. G. Riordan, “Engage to excel: producing one million additional college graduates with degrees in science, technology, engineering, and mathematics”. Report to the President, Executive Office of the President.

[2] S. Peuker, and N. A. G. Schauss, “Improving student success and retention rates in engineering: an innovative approach for first-year course”, ASEE, 2015 [ASEE Annual Conference & Exposition, Seattle, Washington]

[3] N. N. Brown, J. Velarde, and D. J. Mascaro “Using peer mentoring to enhance student experience and increase retention in mechanical engineering” June 2016 [ASEE Annual Conference & Exposition, New Orleans, Louisiana. 10.18260/p.27157]

[4] T.L. Strayhorn, College Students’ Sense of Belonging: a Key to Educational Success for All Students, 2nd ed., Routledge. https://doi.org/10.4324/9781315297293

[6] J. Fiegel, B. Rundlett, A. A. Bradley, and K. R. Murhammer, “Piloting an ethics choose-your-own adventure activity in early engineering education” ASEE, July 2021 [ASEE Virtual Annual Conference Content Access, Virtual Conference. 10.18260/1-2—37580]

[7] ABET. "Criteria for Accrediting Engineering Programs, 2020-2021." https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accreditingengineering-programs-2020-2021/.

Appendix A. Description of each week

1. **Ice Breaker Challenge:** Mentors lead students through various levels of questions starting with 'What was your biggest challenge today?' and continuing to discuss larger time frames. The activity is designed to have students recognize that many of them are experiencing the same challenges at this time in their lives even if they have very different prior life experiences. Students form bonds with their peers and mentors.
2. **Studying:** Through the study and building of model air rockets, students see how different the results of each study method are. Mentors lead discussions on which type of studying has worked for group members in the past. It is emphasized that students need to learn how to efficiently and effectively study while classes are "easier", so they are prepared for the rest of their education.
3. **Intro to Your Discipline:** Alumni 'speed mentor' groups on their undergraduate careers, career to date, and answer any questions the students have. The goal is for students to see the broad range of careers an engineering degree can lead to and to not be discouraged if they aren't interested in the first experience they have.
4. **Resume:** A resume is a physical representation of the 'blank slate' students have as first-year students. Through a Lego design and build challenge, student see how difficult it can be to achieve a goal without proper supplies (representing skills, experience, and knowledge). It is explained that while you can get a degree only going to class, student should participate in activities (student design teams, co-op education, societies, and undergraduate research) that will provide tools that prepare them for their dream career.
5. **Networking:** Building a network is another important tool for students to develop. During this event, students meet with others and practice their elevator pitch introductions. After each has introduced themselves, students are able to trade an item. The items, once all collected, are then assembled into a 3-D printed keychain assembly. The goal of the activity is to connect to enough people so that the students have all the parts needed to complete the assembly.
6. **Opportunity Fair:** Now that students have thought about their end goal and understand the tools needed to have success, students use their networking skills to find opportunities. All CEPS student organizations, design teams, undergraduate research opportunities, and graduate school options are invited to attend an opportunity fair. In a low-stress environment, ZEFS students can easily find and join the organizations of their choosing.
7. **Failure:** Whether electrical, mechanical, or academic, failure is an inescapable part of engineering. Often, students have not experienced failure in the academic setting. ZEFS wants to ensure they have the tools to properly handle failure when the time comes. Looking at the cause of the failure and the lesson it provides prepares students to learn from the experience instead of looking to change programs.
8. **Engineering vs Engineering Technology:** Many of our programs are closely related to each other. We want students to hear the true differences between these programs and the associated career trajectory from experienced faculty. This aims to make sure that if a student changes paths, it is a well-informed decision.

9. **Your Plan:** Students have had time and experience to think about their goals. Your Plan is the path to achieve those goals. 'A failure to plan is a plan to fail'. ZEFS helps students not just plan their curriculum, but their daily schedules. Back-up plans and alternatives are discussed. Advisors are present to help with scheduling questions and mentors to guide them through their first time of adding courses to their spring schedule.
10. **Report Writing:** Report writing is a topic that founders felt is underemphasized in early classes. This leads to disappointing reports in Physics I and II, and then senior design and other high-level courses. Through the building of a model based on student-written instructions (write-it, do-it activity), this hands-on exercise teaches the importance of concise, detail focused technical writing.
11. **Engineering Design Cycle:** The engineering design cycle is an important cycle to not only learn but put into practice. It is taught in this setting through the design-build paper airplane exercise. The engineering design cycle applies to their homework, projects, co-ops, and design teams.
12. **Ethics:** Good ethics save lives. This activity demonstrates to students the importance of practicing good ethics through a choose-your-own-adventure based on a real world scenario. A great time to address this topic is during students' freshman year [5].
13. **Stress Management:** Placed strategically near the end of the semester, different examples of managing stress are discussed. Students will try breathing exercises, take a walk with friends, enjoy delicious treats, and do simple puzzles and coloring activities to help mitigate stress. The causes and effects of stress are discussed and resources for outside help if students feel they need it are provided.
14. **Mini Boat Competition/Professor Social:** College Students Sense of Belonging states that students interacting with professors outside of the classroom is twice as effective at making a student feel that they belong (T.L. Strayhorn). Professors attending the social at the end of the program are meant to start relationships that will allow students to feel comfortable going to office hours and see their professors as there to help them succeed. The mini boat competition is a fun activity that doesn't carry the weight of a grade. It's meant to be a fun outlet to get their minds off school for 45 minutes.

Appendix B: Survey Used to Evaluate Student Feedback

Student: Participation in this survey is optional. Participation or abstention from this survey will not affect your academic performance.

1. Student name
2. Who is your tools lecture instructor?
3. How often do you attend the discussion portion of your tools course (ZEFS)?
4. I feel I understand what Mechanical Engineering/Aerospace Engineering is.
    a. Extended response
5. I feel confident about managing college-level classwork.
    a. Strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree
6. I feel confident about managing college life.
    a. Strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree
7. I know where to seek help on campus when I am struggling academically.
    a. Strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree
8. I know where to seek help on campus when I am struggling financially.
    a. Strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree
9. I know one of our ME professors well enough that I feel I can approach him/her if I have questions or need help.
    a. Strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree
10. I have a peer group that would support me.
    a. Strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree
11. I feel comfortable making wood furniture.
    a. Strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree
12. I know how to be a successful engineering student.
    a. Strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree
13. I feel that I belong at UA.
    a. Strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree
14. I feel that I belong in the College of Engineering and Polymer Science.
    a. Strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree
15. On average, how often do you meet up with your mentor and/or teammates most weeks? (included on the post-survey only)
    a. Several days most weeks, once most weeks, less than once per week
16. What is your fondest memory of Friday's ZIPS: Engineered for Success Program? (included on the post-survey only)