2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
ASEE
Paper ID #39138

A Systematic Implementation of Four Versions of a Course-Based Intervention to Reduce Attrition Among Civil Engineering Students: Overall Study Design and Implementation of First Version

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INTRODUCTION

Nationally and internationally, STEM majors experience more attrition and longer times to graduate than other majors. The high rate of attrition has been documented from a public policy standpoint at various universities in the United States, United Kingdom, Australia, and South Africa [1]. The cost of attrition is significant. Students who attrite are personally burdened by the cost of a partial education when the costs of college are rising [2] and by the loss of income from a lucrative STEM career. Socially, attrition of STEM majors reduces the size of the workforce at a time of high demand for skilled college graduates [3]. The cost of attrition is particularly detrimental to underrepresented minority (URM) groups who attrite in larger numbers [4], and to the diversity of the future workforce.

Researchers who study attrition largely agree that that it is driven by financial issues and personal circumstances; poor preparation for higher education; weak institutional and/or course match; unsatisfactory academic experience; and lack of social integration [5]-[7]. The process of attrition can be understood through longitudinal models, such as the one developed by Tinto [8] that mechanistically relates students' background traits to their initial goals and institutional commitments, and in turn to their integration into formal and informal academic systems (i.e., academic performance and faculty/staff interactions, respectively) and formal and informal social systems (i.e., extracurricular activities and peer-group interactions, respectively), and in turn again to their decision to persevere or attrite. In a survey of our civil engineering students at The City College of New York [9], we found that retained students (i.e., our seniors) were more likely - at the beginning of their studies - to have appreciated the importance of critical technical competencies and the need for social and cognitive skills and strategies around learning and being, than did students who were not retained (i.e., the majority of the entering population of students beginning their major courses).

To improve retention rate, many engineering programs have elected to employ an intervention. There are a considerable number of interventions for engineering majors, and not all are documented in the literature. As reported [10], the engineering interventions vary considerably in terms of target population, whether required, delivery method, and engagement approaches. Some interventions include technical content but most focus on improving the match of the student to the institution and major, and specific core competencies.

OVERARCHING RESEARCH DESIGN

The research presented in this paper is a component of the overarching research program illustrated in **Figure 1**, to develop an intervention that reduces the rate of attrition of students enrolled in the Baccalaureate Program in Civil Engineering at The City College of New York. The shading indicates the components of the research addressed in this paper.

Although attrition is a problem nationally and internationally for all STEM majors, our interest in the subject began with (1) observations of low passing rates and high attrition rates of our own students at the point in time when they first begin their major courses. With the intent to develop a data-driven intervention to address this problem, the research continued with (2) an attempt to better understand the drivers of attrition. This included a literature review of the causes of attrition in STEM majors, and a survey of our civil engineering students to document which attitudes and behaviors could potentially lead to attrition so as to confirm the literature. The research then looked to (3) develop an improved understanding of the interventions that already exist. Since many engineering programs have some form of intervention for their entering students, but not all are documented in the literature, we reviewed the literature to learn about the goals, design, and effectiveness of existing interventions, and then surveyed civil engineering faculty nationally about unpublished interventions.

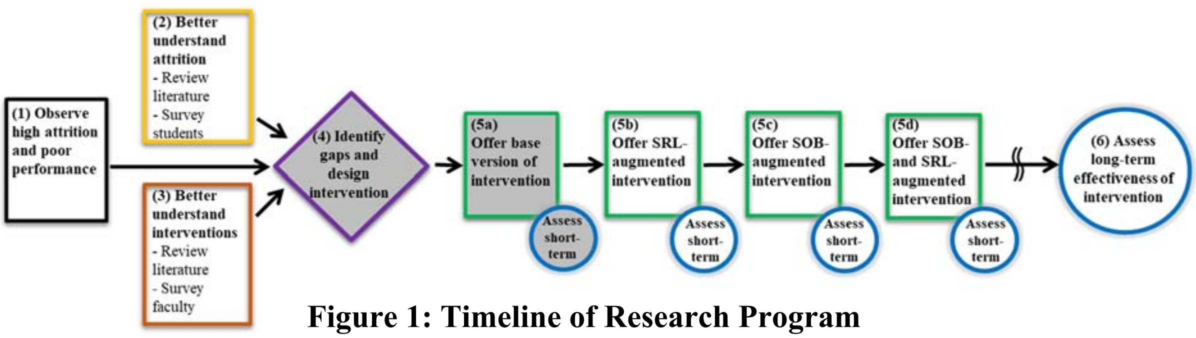

Figure 1: Timeline of Research Program

In the current work, we (4) identify a gap in how current interventions address attrition and design a new intervention to bridge this gap. Four total versions of an intervention to address the gap will be offered for two to three semesters each and statistically assessed to understand short-term effectiveness. We also (5a) detail the design of the base intervention and present the preliminary results of its short-term effectiveness.

In later work, we will provide detailed descriptions of the three augmented versions of the intervention (5b-d) and assess the short-term effectiveness of each. The research will conclude with (6) a longitudinal statistical study of the effectiveness of all four versions of the intervention in terms of retention, speed to graduation, and student performance in major courses. Based on these results, the superior version of the intervention will be identified.

Through this research program, we lay the foundation for future efforts to expand the intervention for broader use in associates and baccalaureate programs in STEM.

GAPS BETWEEN RETENTION MODELS AND INTERVENTION APPROACHES

The already agreed-upon drivers of attrition have social and cognitive associations, as evidenced by the words used to define them: “poor” (preparation for higher education), “weak” (institutional and/or course match), “unsatisfactory” (academic experience), and “lack” (of social integration). While retention models are still a subject of research, they consistently relate students’ decisions to persevere or attrite to their level of academic and social engagement [9]; this infers that the social and cognitive aspects of each potential point of departure along a students’ timeline play an important role in reshaping their intentions, and in influencing their subjective evaluations of college and their retention decisions.

While retention models recognize an association between student-faculty interactions and relationships and retention, and academic and social engagement in college and retention, they do not specifically connect students' Sense of Belonging (SOB) in college to retention. Strayhorn's social-cognitive model of SOB [11] focuses on an individual's cognition, affects, and behavior around their perception of themselves as legitimate members of a community who are valued, accepted, included, and involved. SOB is essential to sustain motivation in individuals, and is a vital foundation for academic engagement, achievement, and retention [11], [12]. Additionally, a college student's need for belonging must be satisfied *before* any other higher-order needs can be met including knowledge acquisition and self-actualization [11], [13]. It is also a pre-cursor to motivation and engagement [14], [15], and sustained academic performance [16], [17]. Therefore, it is critical, and especially for students who are the most vulnerable to attrition such as URM, to develop a strong SOB early in a college career [18].

Similarly, while retention models recognize the importance of academic success and intellectual growth to retention, they do not connect effective Self-Regulation of Learning (SRL) to retention. Zimmerman's social-cognitive model of SRL [19] focuses on an individual's cognition, actions, and affect while learning. Effective SRL occurs when learners are actively engaged in the task (or performance in SRL-speak) and bookend each task with forethought and self-reflection. The *forethought* phase occurs before learners begin work on the task and influences how they engage in the task and their ability to succeed in it. In this phase, the learners analyze the task, assess their motivational beliefs, and plan strategies to successfully obtain their goals and complete the task. In the *performance* phase, the learners undertake the task, using self-control to adhere to their planned strategies and self-observation to monitor their progress and evaluate their work. In the final phase, *self-reflection*, learners use self-judgment and self-reaction to reflect on the effectiveness of the strategies they used during the performance phase and their need for future improvements. Causal attributions only affect self-feedback positively when learners attribute setbacks or failures to internal, controllable, and stable causes that can be remedied [20]. The outcomes of the final phase of self-regulation inform the first phase applied to a new but similar task. The result is a personalized and adaptive learning process that is proactive and self-motivated, and that addresses academic and adjustment difficulty and resolves educational and occupational goals [15], [19], [21]. However, college students need effective SRL not only to meet the demands of their majors, but also because SRL is foundational to key competencies such as critical thinking [22], design [23], and life-long learning [24].

When the SOB and SRL social-cognitive models are overlaid onto a retention model, it appears that students might be better retained if their social-cognitive disposition with respect to attrition was supported by social-cognitive skills and strategies adapted from SOB and SRL models. However, of the many interventions currently being employed, most focus on improving the match of the student to the institution and major, and specific core competencies. While this does recognize a cognitive element of student success (i.e., how a student thinks about their major impacts their decision to remain in it), it does not fully support SOB. Although they are a minority, there interventions at the college level for engineering majors that specifically address SOB [18] or self-efficacy [14]. Self-efficacy is an important but small element of these socio-cognitive models, but focused coverage is unlikely to fully support SOB or effective SRL.

This works seeks to develop and assess an intervention to reduce attrition by specifically training students in the skills and strategies adapted from the social-cognitive SOB and SRL models.

Unlike other interventions, it interweaves adaptations of the SOB and SRL models for synergistic benefit to students. Because the degree to which skills and strategies around SRL and SOB need to be introduced to make the largest impact to retention is unknown, four versions of the intervention are proposed that vary the degrees to which SOB and SRL skills and strategies are addressed. They include:

- Base intervention (which provokes students to think about their learning and belonging);
- Base intervention augmented with specific training in effective SRL;
- Base intervention augmented with specific training in SOB; and
- Base intervention augmented with training in effective SRL and SOB.

SYNTHESIS OF NEW INTERVENTION

In our future envisioning of the intervention, all students within a single major would participate in an intervention tailored to include the technical and professional content appropriate for the major. Students within a major would participate regardless of their sub-specialization interests or how they joined the major (i.e., as a freshman or transfer student) to ensure a consistent foundation for later reinforcement or growth.

The current envisioning of the intervention is designed for students enrolled in civil engineering baccalaureate programs. Logistically, it is offered as a required credit-bearing course to ensure that students meaningfully participate in its curated delivery of strategies and activities; This also allows the course to be relevant and timely because students can be required to complete it at the important potential point of departure when they first begin their major courses. It is standalone to give students time and space to develop the new skills and strategies. Although it is non-technical, the skills and strategies introduced in the intervention are applied to topics and materials from their other technical major courses. The course meets for 1.5-contact hours per week, front-loaded in the first half of the semester so students have opportunities in the same semester to use the new knowledge to improve learning in other major courses, and to build sense of belonging in the major and the college at this critical time.

The intervention content is curated to address the key drivers of attrition. Learning and belonging are threaded throughout the intervention, since all of the drivers have social and cognitive aspects. "Poor preparation for higher education" is addressed specifically by discussing the *importance of requisites* to major courses, providing hands on activities to apply requisites to technical major problems, and having students self-assess topic knowledge. Students are connected to *helpful major resources* such as pre-requisite intensive sessions during the academic breaks, and instructor office hours and peer-peer tutoring in the present semester. If our curriculum did not already include an introductory course that addresses the *profession and career paths and the curriculum*, and that connects students with alumni/practicing engineers, these important topics would be included in the intervention as well, to address the "weak institution and/or course match" driver. The intervention addresses the "unsatisfactory academic experience" driver by provoking students to explore the difference between their own expectations of college and the demands of the major and profession; we do so by guiding them to develop other *key competencies* (e.g., critical thinking, design), and by bringing in seniors as guests to talk about their *responsibilities as college-level learners* (e.g., know what is expected, do the work, manage time, present work clearly, write effectively, create productive groups, and communicate professionally). A "lack of social integration" is addressed by providing weekly *opportunities to connect* with their peers (e.g., partnered in class activities, peer tutoring), with faculty (e.g., office hours, one-on-one advisement sessions), and with major resources (e.g., study rooms, major events like mixers, college events like career fairs).

The content delivery is designed to be engaging and student-centered. Experiential learning approaches such as active learning, project-based learning, and service learning are the norm in the intervention, as is engagement with challenging and relevant content to develop ability and commitment. Lectures introduce each topic and guided in-class activities have students practice skills and strategies in groups on technical problems from major courses. Homework challenges students to assess and refine in-class activity work; incentivizes them to explore helpful resources and self-reflect on their experiences; and prompts them to set goals for improvement and identify steps to take to improve their future experiences.

BASE VERSION OF INTERVENTION

This section addresses the base intervention design, the methods used to assess its short-term effectiveness, and the preliminary results of its first offering in Fall 2022.

Design

The base design of the intervention is meant to be easily implementable. Its content addresses the key drivers of attrition, which reorganized include the expectations of the major and profession, and other competencies for the major. Students are exposed to skills and strategies around learning and belonging, but in a limited manner and without discussion of SRL and SOB socio-cognitive theories, as shown in the topics and learning objectives given next.

Topics

1. Student responsibility: know what is expected, do the work, manage time
   - 1 class
2. Relevant math, science, and computer science concepts
   - 3 classes
3. Critical thinking: Concept and use of engineering method to prompt it
   - 4 classes
4. Professionalism: Present problems solutions clearly, write effectively, create productive groups, communicate professionally, build network
   - 2 classes
5. Learning: Deep understanding, growth mindset, levels of learning strategies, self-assessment
   - 4 classes

Learning Objectives

a. Take full responsibility for learning
b. Manage your own time
c. Know pre-requisites of new course
d. Connect math concepts to civil engineering
e. Connect physics concepts to civil engineering
f. Connect computer science concepts to civil engineering
g. Use the engineering method
h. Use critical thinking
i. Present work clearly to others
j. Understand yourself as a learner
k. Nurture a growth mindset
l. Set personal goals for learning, performance, and your feeling about both
m. Use efficient and productive strategies to deepen understanding
n. Self-assess regularly to monitor progress and redirect efforts
o. Think about how you feel about your performance and your work
p. Think about how you feel about being a part of the major and the college
q. Actively work to build your sense of belonging in the major
r. Connect with other students in class and in study groups
s. Connect with faculty in class and office
t. Participate in activities on campus
u. Report technical information well to a specific audience
v. Become familiar with and use professional communication
w. Use strategies to help groups to be more efficient and productive

Instead of training students in skills and strategies adapted from the SRL model, students are introduced to concepts relevant to SRL (i.e., being self-motivated, setting goals, creating and following plans, and using self-assessment to redirect efforts) and asked to apply these concepts to scheduling time, studying, and test taking. Instead of guiding students in developing and maintaining their SOB, students are connected with relevant people and resources to ground them in a sense of belonging. They meet with graduating seniors who share "what they wished they had known when they started and why", they are partnered with their peers during in-class activities, and they are incentivized to explore helpful resources and connection opportunities such as studying in a common space dedicated to the major, studying in a group of peers, attending office hours, and going to major events.

Assessment Methods

The methods introduced in this paper are limited to the two analyses of the short-term effectiveness of each of the versions of the intervention.

The first analysis statistically evaluates student ratings reported on an end-of-course survey conducted in the final class period in Fall 2022 to understand the perceived importance and helpfulness of strategies introduced in the intervention, and the rate at which students used these strategies in other major courses. The survey was designed to be as short as possible to maintain student engagement for its entirety and used similar language as employed during lectures and activities to ensure that students understand the questions. The statistics of the ratings are visualized using box-whisker plots. As shown in **Figure 2**, the endpoints of the boxes show the minimum data value in the first quartile and the maximum data value in the third quartile of data; the median value is the line in between these quartiles. The whiskers show the minimum and maximum data values that are 1.5 times the inter-quartile range (IQR) from the box edge. Data values that are outliers are shown as points outside of the whiskers. Histograms accompany each plot to illustrate the modality of the data. Our goal is that a minimum of 75% of students complete the assessment, and that student ratings are unimodal, tightly distributed, and skewed high near a value of four out of five. Possible sources of bias to this first assessment include student ratings assigned without much thought, and questions answered with several responses instead of the best one.

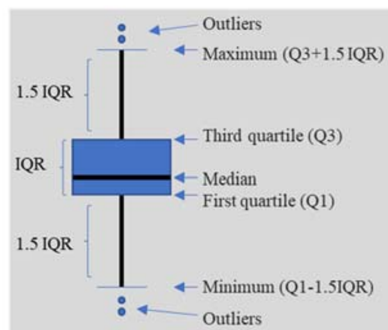

Figure 2: Box Plot Statistics

The second analysis evaluates whether student performance in the first two major courses in the curriculum (i.e., Statics and CE Data Analysis), and student persistence into the following semester, improved as a result of the intervention. Both analyses are based on the grades of students taking either major course in Fall 2021 (i.e., without the intervention) or in Fall 2022 (i.e., with the intervention). After omitting the grades of repeat-takers, the remaining student grades are aggregated into two bins: pass, and not pass. The percentage of students passing and not passing each course is computed. To assess student persistence, the same grade rosters are used but now only the subset of students who did not pass the major course in Fall 2021 or in Fall 2022 are considered, looking to see if they re-enrolled in the same course in the next semester. Their grades are then aggregated into two bins: retake, and not retake. The percentage of students retaking and not retaking each course is computed. After calculating the passing rates and persistence rates, a Fisher's Exact hypothesis test [25], [26] is used to determine if the differences in the rates with and without the intervention are statistically significant. This test was selected because of the limited sample size of the data and the contingency nature of student performance (i.e., pass or not pass) and student persistence (i.e., repeat or not repeat). For example, for the student performance analysis, the null hypothesis H_0 is that the passing rates of students in each major course are the same regardless of whether they participated in the intervention, and the alternate hypothesis H_A is that the passing rates of students are higher for students who participate in the intervention. The null hypothesis H_0 is rejected when the value of the test statistic, p, is less than a threshold value; we employ the common threshold of 0.05. Possible sources of bias to the second assessment are differences in student performance due to different instructors, different levels of preparation, and personal or pandemic-related reasons.

Preliminary Results

Analysis of Student Ratings

The formative assessment was deployed on the final day of class with 86% of students participating (i.e., 38 of 44). The sections that follow detail the student ratings of a sampling of the technical competencies introduced in the intervention, one at a time: professionalism, pre-requisite knowledge, and critical thinking. Skills and strategies adapted from the complete socio-cognitive models of SOB and effective SRL are not directly assessed as they are not included in the base intervention. However, learning effectiveness in a broad sense is included. Due to an oversight, belonging was omitted entirely from the survey.

Technical competency - Professionalism Examples of professionalism skills include presenting problem solutions clearly, managing time well, and working effectively in groups. The lectures on each topic presented the need for the skill in the workplace, and the benefits of mastery. Students had opportunities to practice their problem presentation during in-class activities. Students were prompted on homework to self-reflect on their strengths in all of professionalism areas and set goals for improvement.

Figure 3 presents the student self-assessments of the professionalism aspects of the intervention. The perceived helpfulness and use outside of class are shown separately, in pairs for each concept.

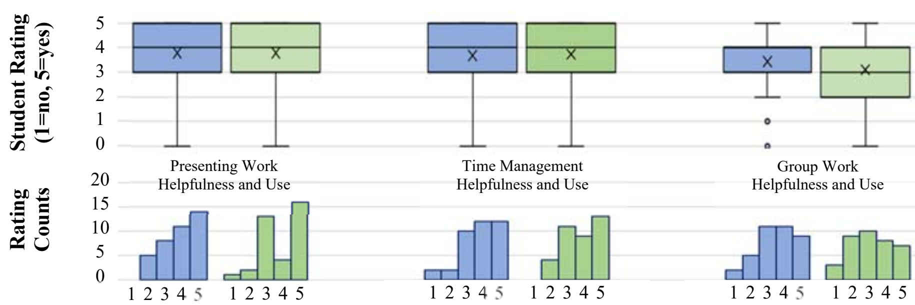

Figure 3: Assessment of Professionalism Aspects of Intervention

Student perception of these key professionalism skills ranged. While the ratings for presenting work and time management are skewed high, with tighter distributions for time management, the use ratings have bimodal distributions. Comments on the formative assessment indicated that some students entered with strong skills in both of these areas and were frustrated to have to complete assignments that they considered to be unnecessary. This is always a challenge of an intervention: the initial differences in strengths and needs of enrolled students. The ratings for group work were lower and more distributed; likely because students were not asked to complete a group project and so their exposure to this topic was less practical.

Technical competency - Pre-Requisite Knowledge A lecture reinforces the importance of pre-requisite material and in-class activities demonstrate the relevance of requisites to concepts in major courses and the high level of recall needed to solve major problems.

- Math activity: Analyze surveys using vectors, assess material properties like spring stiffness.
- Physics activity: Connect forces on suspension bridge, calculate centroids on a building wall.
- Computer science activity: Write pseudo code to analyze a set of extreme wind pressure data.

Figure 4 presents the student self-assessments of this portion of the intervention. The perceived helpfulness and use outside of class are shown separately, in pairs for each pre-requisite.

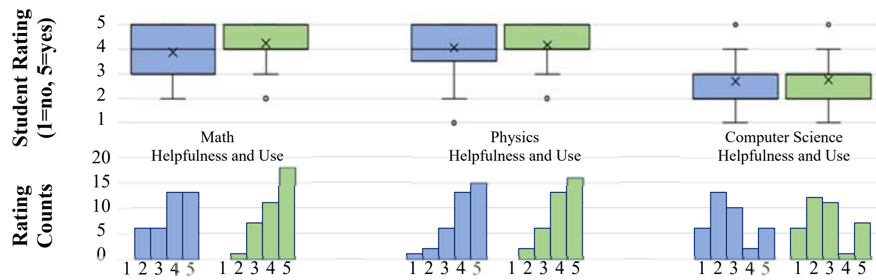

Figure 4: Assessment of Pre-Requisite Aspects of Intervention

For math and physics, the student ratings are skewed high, and have relatively tight unimodal distributions. Interestingly the ratings on use are even higher than those for helpfulness. The exception is for the ratings of the activities for computer science connections to civil engineering which are rated lower in both helpfulness and use outside of the intervention, and that have bimodal distributions. Possible explanations are that students lacked understanding of the relevance of computer science to civil engineering (i.e., as evidenced during an in-class discussion), that they found this activity to be more challenging than the others (i.e., as commented on the survey), or that they merely began the intervention with greater familiarity of math and physics than computer science. This highlights the need for interventions to be introduced early enough so students know to invest effort into the important requisite topics.

Technical Competency - Critical Thinking An initial lecture introduces the concept and the use of the engineering method to prompt critical thinking. Students then practice critical thinking in multiple class periods through guided problem solving activities.

- Activity: Analyze bridge failure for live loads on cantilevered bridge.
- Activity: Statistically analyze simply supported beams and loads on inclined planes.
- Activity: Design the dimensions of rectangular gravity dam.
- Activity: Determine soil compaction to support deck with columns, beams, girders, and slab.
- Activity: Design deck for 50-year snow load and conduct reliability analysis of design.

Figure 5 presents student assessment of the critical thinking topic. The first six plots present perceived helpfulness, and the final two plots present use in other major courses.

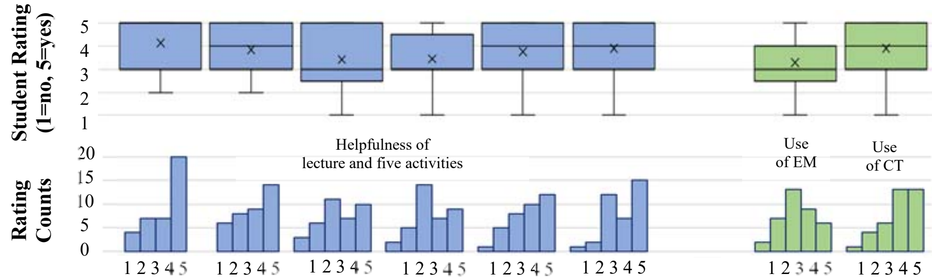

Figure 5: Assessment of Critical Thinking Aspects of Intervention

All student ratings are skewed high, meaning that the majority of students found coverage of this concept to be helpful and began using it in their other major courses. Most rating medians are at our target rating of four, and most activities have ratings with unimodal distributions, but the data spread is larger than desired. Several student comments on the formative assessment suggest that the critical thinking activities were overly challenging and rapidly paced. Interestingly, students report they were more likely to use critical thinking than to use the engineering method in their other technical courses; for the basic problems they are solving, the engineering method may be perceived as being too cumbersome.

Learning Several lectures introduce students to different levels of learning strategies, and examples of specific strategies for each level. In class activities prompt students to practice these strategies in groups on graded homework and quizzes from other major courses.

- Synthesize old problems activity: Generalize how concepts are referred to in problem statements; explain concepts in your own words; and write out governing equations for a concept and explain the physical meaning of each term.
- Synthesize new problems activity: Identify unassigned problems for more practice of a concept; modify already solved problems to increase difficulty and explain how the modification changes how the problem is solved; and seek help.
- Test understanding activity: Create visual aids to inform and test understanding; analyze how a problem is similar to or different from other problems including its solution; predict the expected answer; and explain which approach is best to solve a problem and when.

Figure 6 presents student assessments of the limited coverage of learning in the base intervention. Perceived helpfulness is shown first, and use in other major courses is shown second.

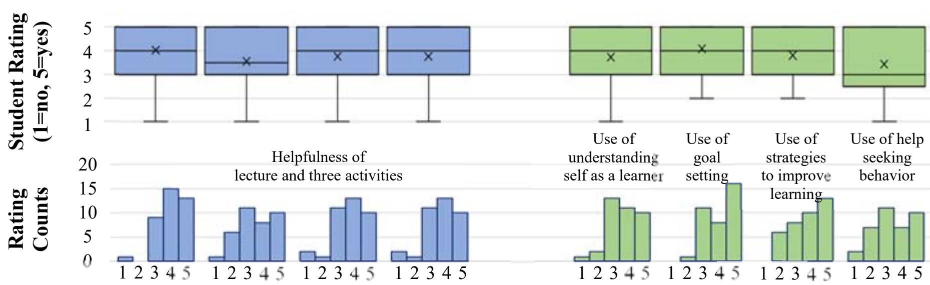

Figure 6: Assessment of Learning Aspects of Intervention

The ratings are skewed high, indicating that a majority of students found coverage of this concept to be helpful. Most of the rating medians are at our target rating of four. The lecture and all but one of the activities have tight unimodal distributions. The use ratings are also skewed high, although the distributions for the use of learning strategies and seeking help are broader. As these two uses are important for SRL, refinement in their instruction is needed.

<u>Analysis of Grades in Major Courses</u>

The first analysis of student ratings indicated that students found much of the intervention to be helpful and even implemented skills and strategies they learned in the intervention in other major courses. This second analysis evaluates the effect of the intervention on student performance in the major courses they took alongside the intervention: “CE Data Analysis” and “Statics”.

As shown in **Table 1**, the passing rates of first-time takers in major courses are greater for students who received the intervention than for those who did not. However, only differences in performance in "CE Data Analysis" are statistically significant with 95% confidence.

Table 1: Assessment of Impact of Intervention on Performance and Persistence in Major

	Performance of Sophomores in Sophomore-Level Major Courses			Persistence of Failing Sophomores to Retake Course in the Next Semester		
Major course: CE Data Analysis	**# Pass**	**# Not Pass**	**% Pass**	**# Retake**	**# Not Retake**	**% Retake**
Without intervention (Fall 2021)	5	55	8%	29	26	53%
With intervention (Fall 2022)	8	26	24%	21	5	81%
Fisher Exact Test p-value	0.043			0.013		
Major course: Statics	**# Pass**	**# Not Pass**	**% Pass**	**# Retake**	**# Not Retake**	**% Retake**
Without intervention (Fall 2021)	15	27	36%	24	3	89%
With intervention (Fall 2022)	17	26	40%	19	7	73%
Fisher Exact Test p-value	0.44			0.13		

The persistence rate of students who failed a major course varies depending upon the course. For "CE Data Analysis", the persistence rate is greater for students who received the intervention than for those who did not; this observation is statistically significant with greater than 95% confidence. However, the persistence rate of students who failed "Statics" appeared to decline although these findings are not statistically significant.

While the bias from repeat-takers was removed, other potential sources of bias to this analysis remain: differences in instructors, student preparation, and personal or pandemic-related issues.

DISCUSSION

The first offering of the base intervention was met with overwhelmingly positive reception. The feedback from students who participated in the intervention suggests that the topics are relevant and comprehensive. Connecting this to prior work, the two cohorts of students (i.e., sophomores, juniors, and seniors surveyed in Fall 2021 and the sophomores participating in the intervention in Fall 2022) are not significantly different in this manner, and therefore that the content areas selected based on the Fall 2021 cohort appear to still be relevant for the Fall 2022 cohort.

The preliminary results for the base intervention indicate that students found the skills and strategies related to the major and profession to be largely helpful and they implemented them in other major courses. The bimodal distribution of ratings for some questions may be explained by some students entering the intervention with more awareness of particular intervention topics than others and therefore finding the activities to be less helpful. The breadth of the distributions of ratings for many questions may be explained by the lack of a take-home resource that uses the same language to present particular topics as used in the lectures and in-class activities. In its first offering, students were given handouts from a wide array of sources; since they were repurposed, they did not speak directly to the topic at hand, and this might have challenged uptake of concepts and their application beyond the intervention.

Instead of specific instruction on self-regulation of learning, students were taught basic learning skills and strategies; the ratings indicate that they found them to be helpful and they implemented them. Instead of specific instruction on sense of belonging, students were connected with places and people to help them cultivate a sense of belonging in the major; however, it is unclear whether these attempts actually had an effect on students' SOB as these questions were inadvertently omitted from the formative assessment tool.

The preliminary results also indicate that participation in the intervention had a positive effect on student performance in both of the major courses but an inconsistent effect on their persistence in the major for another semester. The performance of students in "Statics" improved but this increase was not statistically significant, and the persistence of these same students actually decreased. The performance of students in "CE Data Analysis" and the persistence of these same students both improved and the increases were both statistically significant. This is possibly explained by an early awareness of the importance of physics to statics, and of statics to the major, but a lack of awareness of the importance of programming and data analysis to the major. As a result, the intervention may have alerted students to the need to rethink how seriously they approached "CE Data Analysis".

The preliminary results also highlight a need for revisions to the instrument design. A common challenge of optional surveys is obtaining a high response rate and maintaining strong engagement. In this case, the response rate was high because it was administered in class and students appeared to be engaged throughout the survey as evidenced by the near perfect completion rate of the survey and side-comments added throughout the survey. However, in an attempt to create a survey that was short enough to maintain engagement, topics were grouped which confounded the assessment and questions around belonging were inadvertently omitted.

RECOMMENDATIONS

In the two future offerings before the next version of the intervention is introduced, several elements should be revised; after which the short-term effectiveness should be reassessed. The intervention should include opportunities for students with pre-knowledge of the intervention topics to advance more quickly. It should also have a cohesive resource outside of class that uses the language used to present particular topics in the lectures and activities, to help students improve their uptake of concepts and their application of them outside of the intervention. Another recommendation is to revise the formative assessment. Before the next offering, topics that were grouped for brevity's sake should be thoughtfully expanded. Specific probative questions around student effectiveness of learning and sense of belonging should be included so that the same survey can be given to students in all versions of the intervention, and not just the base intervention. Questions probing possible confounding factors like whether pre-requisite courses were taken online should also be included so these biases can be addressed in the analysis.

CONCLUSIONS

This work seeks to develop and assess a retention intervention that addresses the key drivers of attrition and learns from existing interventions. The intervention is ultimately intended broadly for STEM majors in associates and baccalaureate programs, but is being developed first for civil engineering baccalaureate students. The intervention addresses key competencies for the major and profession, and also addresses a gap in current approaches: the need to support students' social-cognitive disposition with respect to attrition by synergistically training them in social-cognitive skills and strategies adapted from the theories of Sense of Belonging (SOB) and Self-Regulation of Learning (SRL).

Because the degree of skills and strategies around SRL and SOB needed to make the largest impact to retention is unknown, four versions of the intervention are proposed: A base intervention which provokes students to think about their learning and belonging, an intervention augmented with specific training in effective SRL, an intervention augmented with specific training in SOB; and an intervention augmented with training in both effective SRL and SOB. An overarching research design plans the offering and assessment of each version of the intervention, including a numerical longitudinal analysis of retention at the end of the study, with the ultimate goal of identifying which version of the intervention has the largest positive impact to retention and other key metrics.

After a general description of the intervention as a whole, the focus was reoriented to the base version of the intervention and preliminary results for its first offering in Fall 2022. The base version addresses key competencies for the major and profession, and introduces students to learning and sense of belonging without training them in specific skills and strategies adapted from the SRL and SOB models. Overall, students found the topics covered in the intervention to be helpful and many used the skills and strategies from the intervention in other major courses. Students who participated in the intervention saw a significant improvement in their performance in early major courses, but their persistence rate in the major for another semester only improved for one major course and was inconclusive for a second major course. Recommendations were made to provide opportunities for students with pre-knowledge of the intervention topics to advance more quickly, to refine the reference materials provided to students and several of the activities in the base intervention, and to thoughtfully expand the formative assessment tool to include questions around SOB and SRL so the same assessment tool could be used for all versions of the intervention.